GREEN JOBS NEWSLETTER

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SPECIAL EDITION

Green Hydrogen

Empowering the future

INSIDE THE ISSUE

MESSAGE

Chairman Vision

India is committed to curb its dependence on energy imports and there is need to win the economy away from fossil fuels. By 2030, India is targeting to produce approximately 1 million tons of green hydrogen per annum, which is expected to increase to 25 million tons per annum by 2047.

Green hydrogen has come a long way from just being a buzzword globally. Almost all energy companies across the world are aspiring to make investments in green hydrogen. The recent MOU signed between Tata Steel and American car maker Ford for supplying green steel at Netherland plant, is a testimony to the fact that green hydrogen economy is opening up. The goal is very clear, which is to provide secure energy, affordable energy and clean energy to all.

We have witnessed record temperatures, more heat waves, increased extreme weather events such as floods, cyclones or droughts, drying up of rivers and forest fires all over the world. Global warming is a concern which needs to be addressed on a war footing. We will all agree that global warming does not differentiate between developed or developing countries. All these events related to temperature; soaring temperature have been seen both in developed world as well as developing world.

In 2015, only 25% of the countries had decarbonized horizon. Today it is 90% plus and this is indeed a major shift. Green hydrogen economy will have a significant in achieving our net zero targets. While carbon neutrality agenda continues to be priority for leaders across the world. There are challenges.

There is fortunately alignment again of the all-global leaders, be it organizations or be it prime ministers or presidents of the world. This is alignment on four thoughts, which is good news to my mind. One is there got to be focused on sustainable manufacturing, second is making stride to recycle materials, third is focus on renewables and invest in new sources of sustainable fuels like green hydrogen. Task of achieving carbon neutrality is neither simple nor easy. While there is alignment on these four thoughts all across the world, there are four universal problems which we need to address. Those are the hurdles we all are facing, I'm sure. One is deploying capital at a scale. This green hydrogen dream needs huge investment, second is scaling up supply chain infrastructure. There has been disruption of supply chain globally over the last three years, which we have all witnessed. And unless and until there is a robust supply chain infrastructure available, there are going to be again challenges in implementing this green economy thoughts. Third is managing economic dislocations and fourth is labour and talent shortages. These four are the impediments to faster execution of implementation of this green hydrogen and needs to be addressed systematically

Mr. Sameer Gupta

Chairman

Skill Council for Green Jobs

MESSAGE

From the CEO's Desk

Skill Council for Green Jobs has just complete 8 years of its Operations and now moving into new leap. I am happy to announce that we are setting up of International Academy of Green Energy. This academy would be a division of existing setup of Skill Council for Green Jobs. With the support of the academy, we are planning to strengthen our trainings, training partners and training course materials for higher level of Skills under market mode.

> *"Green Hydrogen, Green Skills and Green Energy are the future of existence"*

Green Hydrogen is expected to play a major role in decarbonizing heavy industries, including oil refineries, steel mills and fertilizer plants. With the adoption of green hydrogen and green ammonia over long term, India aims to be a net exporter of energy which currently we are a net importer of energy and which is a huge drain on our GDP.

With the kind of water availability and the sunshine and even wind, we are blessed to have these resources. We can be a net exporter of energy. But at the same time, this brings huge responsibility on government, on industry and the businesses. I think from industry standpoint, risk appetite needs to be elevated and new ideas need to be supported. It is not the time to ask, has it been done before? It is time to commit, experiment and be innovative. Many companies in India have made significant commitments for making investments in green hydrogen and green ammonia in next few years. SCGJ 's Chairman has announced that Jackson, is committed to make an investment of 22,400 crores for producing green hydrogen and green ammonia. They have made this announcement recently and have signed an MOU with the government of Rajasthan. This investment would be in three phases and Jakson Green will have a total capacity of 250,000 tons per annum and this facility, this investment should create a job of approximately 32000 numbers.

SCGJ's Vision 2047 is that India's shift to clean energy will result in 30-35 million additional jobs across a number of sectors and SCGJ will undertake over 10 million skills trainings and job facilitations. The sectors deemed to have the highest potential for job creation include: green hydrogen, energy storage, hybrid renewable systems, biomass/biofuels, EV charging, pollution control, e-waste management, and decarbonisation of energy intensive industries, etc. In the shorter-term, to 2030, SCGJ aims to facilitate one million short-term trainings in clean energy and green technologies, two million virtual or blended upskilling and reskilling training across all sectors, establish 20 centres of excellence along with 750 affiliate training centres, and create 7 500 certified trainers.

Skill Council for Green Jobs has systematically planned to meet the skilled manpower requirement and is geared to supplement the national efforts of moving towards sustainability. As a next step, SCGJ is looking forward to setup an International Academy of Green Energy.

Dr. Praveen Saxena
Chief Executive Officer
Skill Council for Green Jobs

Governing Council

Seventeenth Meeting

The 17th Governing Council meeting of SCGJ was held under the chairmanship of Mr. Sameer Gupta, Chairman and Managing Director, Jakson Group and Chairman SCGJ

The **Seventeenth Meeting of the Governing Council** of Skill Council for Green Jobs was held on 29th August, 2023, under the Chairmanship of Mr. Sameer Gupta, Chairman and Managing Director, Jakson Group, through video conferencing. 12 Governing Council members were present in the meeting.

In the opening remark Mr. Sameer Gupta, Chairman mentioned that India is witnessing a very important era and fortunatly, as a country have the highest growth rate amongst the top five economies of the world. India is forecasted to double its economy to 6.7 trillion by 2031 from presently 3.4 trillion. So, we are going to be more than double as forecasted by SNP. We know that last year in COP 26 which was held in Glasgow, honorable Prime Minister announced about India achieving net zero by 2070. Our country has actually fast-tracked lot of initiatives in areas of renewable energy, e-mobility, and in particular green hydrogen. Mr. Gadkari intends to launch Toyota Innova which is going to be 100% on ethanol. This is going to be first of its kind in the world. Undoubtedly our country is becoming a global climate leader and we are attracting significant investments both from domestic as well as international sources. There are challenges which includes by the way technology, innovation, policies, investment and of course scaling skilling is one of the challenges. We have the largest population in the world and considering the fact that population in developed world is on decline. He said, I think this is a clean opportunity for India to be skilled capital for the world. Education and skilling are two important pillars which we all know and they need to be integrated to each other. That's what lot of effort again is being done by various stakeholders. The national education policy has brought vocational education and formal education closer than ever. That's something new. Another thing I would say is engagement of industry with education and skills which has become another driver very important driver which will help youth unleash the potential in this sector of skilling. Skill Council of Green Jobs has taken many initiatives to support the sustainable transition towards green economy and for having a sustainable development

India has the honor of hosting G20 conference and we just witnessed successful launch of Chandrayan as well. I think G20 presidency provides an opportunity to the world to benefit from India's achievements in diverse fields now. Including of course renewable energy, digitization and now even space. we are witnessing is just a new beginning, new era for this country altogether. We are aware of various programs launched by government of India to enhance the skill capital with objective of improving skill and employability of its workforce both in India and across the world.

Mr. Sunil Jain, co- chair SCGJ mentioned that the industry will have to keep in mind the advent of the Cross Border Adjusted Mechanism (CBAM) tax which Europe is going to levy on the companies who are exporting to Europe and they have to measure their carbon footprint, This is going to be a lot of requirements for people who can measure the actual carbon content of the products which are being exported. There is a limited expertise available more so in the MSMEs. This is one area which would require tremendous amount of skill and we therefore must start now. He further mentioned that from ethanol and other products, please keep in mind one G will be out very soon and we should start skilling people for 2G, not one G. Mr. K Krishan mentioned that we have to focus on the agricultural residue and waste and towards the second-generation biofuels, and make a push on that program which has already started.

CEO, SCGJ mentioned that we have conducted 6 skill Gap studies during the year on Solid Waste Management in Metro Cities, Jobs and skilling in domestic solar and wind energy sector, Assessments of biomass demand-supply value chain and entrepreneurship development for pellet production, Skill Gap Study on Plastic Waste Management, Green House Gas Accounting Guidelines and Landscape of Green Jobs in India supported by JP Morgan Chase. Dr. Saxena mentioned that SCGJ has completed CSR project from SBI Card, the World Bank Project towards introducing Vocational Education in Renewable Energy in Schools, UNDP Project on Green Electric Vehicle Charging Infrastructure and Solar Cold Storage, Climate Policy Initiative (CPI) Funded Entrepreneurship development and three projects funded by GIZ.

The GC was informed that at the beginning of the year, SCGJ had 44 approved qualifications (17 qualifications in Solar domain, 6 in Wind, 12 qualifications in Bio Energy, 6 in Waste Management, 2 in Sustainable Practices and 1 in Small Hydro). These qualifications were reviewed and revised qualifications have been submitted for approval of NCVET. During 2022-23, 24 new qualifications have been developed and approved by NCVET relating to Solar EV Charging, Solar Cold storage, rain water harvesting, Green Hydrogen and Solar PV cell manufacturing Technician. One of the most important activities undertaken during this period was to broaden the industry base of SCGJ and develop industry associates. Over 650 industry, mainly MSME were contacted and informed about the activities of SCGJ. Industries added this year to our Membership are 26 in number. SCGJ has so far signed MoUs / LoAs with 69 industry / organizations with a view to cooperate in its activities and also help in achieving placement of SCGJ certified candidates. During the year 12 more MOUs were signed. Dr. Saxena briefed the GC about the Short term and RPL trainings and certification conducted by SCGJ through its affiliated training partners and assessment agencies. It was informed that 668 candidates have been certified as trainers for all its sectors. SCGJ has empaneled 8 assessment agencies for carry out the future assessments and conducted Training of Assessor for 103 candidates. During the year, SCGJ has conducted assessment and certification in 8 State Missions. SCGJ has completed the RPL Trainings of more than 7634 sanitation workers supported by NSKFDC across the country.

This was followed by comments of the members which were noted by SCGJ. It was also decided that SCGJ will have four GC meeting per year from now onwards.

The Chairman introduced the agenda for setting up of an International Academy of Green Energy by Skill Council of Green Job. Dr. Saxena made a detailed presentation about setting up of International Academy of Green Energy. He mentioned that we have been talking to various organizations national as well as international and we have been requested by many organizations that they would be able to support if the trainings are of higher level. It would have a strong industry connect, it would take up some projects, CSR projects, it would take some consultancy projects. When we take consultancy projects or take some projects, our own people become wiser and more strengthened. Their knowledge becomes better and they become updated as far as information and knowledge is concerned. CSR projects or contractual projects or contracts or consulting things help us in building our own capabilities and credibility.

Dr. Saxena mentioned that as country, we are looking for moving to 500 GW of renewable energy by 2030 and National Hydrogen Mission looking for about six lakh jobs opportunities in that particular sector. As chairman was also saying we are moving into a network of CNG and PNG and there will be a 20% ethanol blending in petrol. We are moving towards a circular economy and net zero emissions which have been announced by the Hon'ble Prime Minister. We are estimating that there would be about 35 million green jobs which would be created by 2047. It is felt that there should be a more strengthening of our activity which requires a focused attention like center of excellence. We have a large number of international engagements. We have delivered over 4000 trainings for 82 countries ISA member countries in different languages. SCGJ have received assignment from World Bank, UNIDO USAID, FCDO, WHO, GIZ. We are invited by USAID to take Master classes in green hydrogen for Bangladesh, Bhutan, Sri Lanka and Maldives. We are now a member of BRICS Council. We have an MOU with IRENA, IEA, Clean Energy Ministerial . So, lot of traction is coming on green skills and green hydrogen.

The Governing Council accord in-principal approval to set up “International Academy of Green Energy (iAge)” .

The meeting ended with vote of thanks.

Masterclass on Green Hydrogen

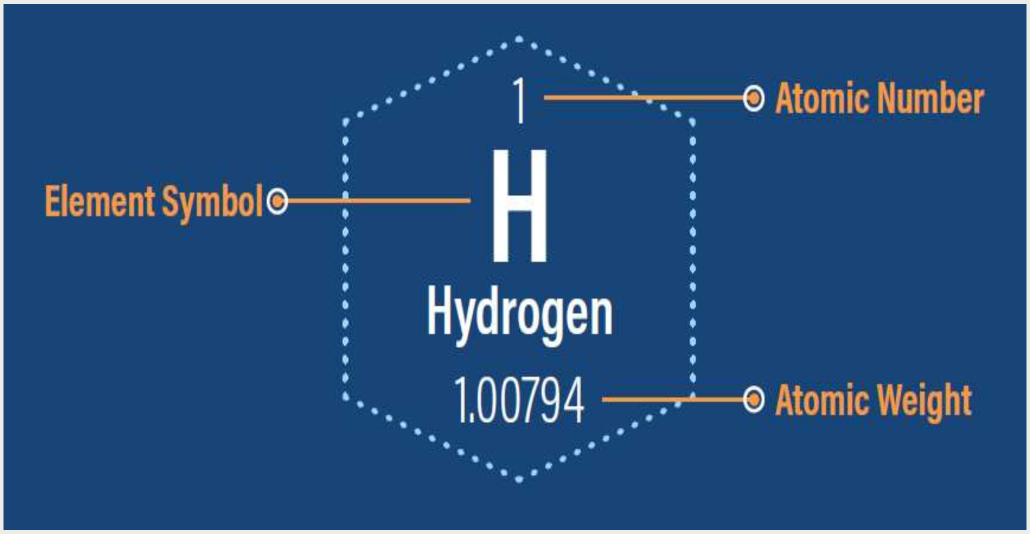
Green Hydrogen Entrepreneurship Masterclass was jointly organized by Skill Council for Green Jobs (SCGJ), GH2 Solar, a Green Hydrogen developer, and National Solar Energy Federation of India (NSEFI) on 4th & 5th Sep 2023 at India International Centre, New Delhi.

Objective:

The objective of the two days industry supported training event was to equip about 30 participants with the necessary knowledge, skills, and competencies to excel as entrepreneurs in the dynamic realm of green hydrogen. A range of industry experts along with Master Trainers delivered the key sessions which covered important insights on technology, policy, financing, regulations and evolving market dynamics of Green hydrogen and its derivatives. Various current & emerging business models suitable for green hydrogen/ green ammonia ventures along with the Contractual agreements for green hydrogen and its derivatives were also highlighted. In addition, case studies of some operational projects were also showcased and emerging entrepreneurial opportunities across the value chain were outlined.

Mr. Sunil Jain, Partner-Essar Power & Co-Chair-Skill Council for Green Jobs, presented comprehensive study on future of Green Hydrogen. The summary of presentation are as follows:

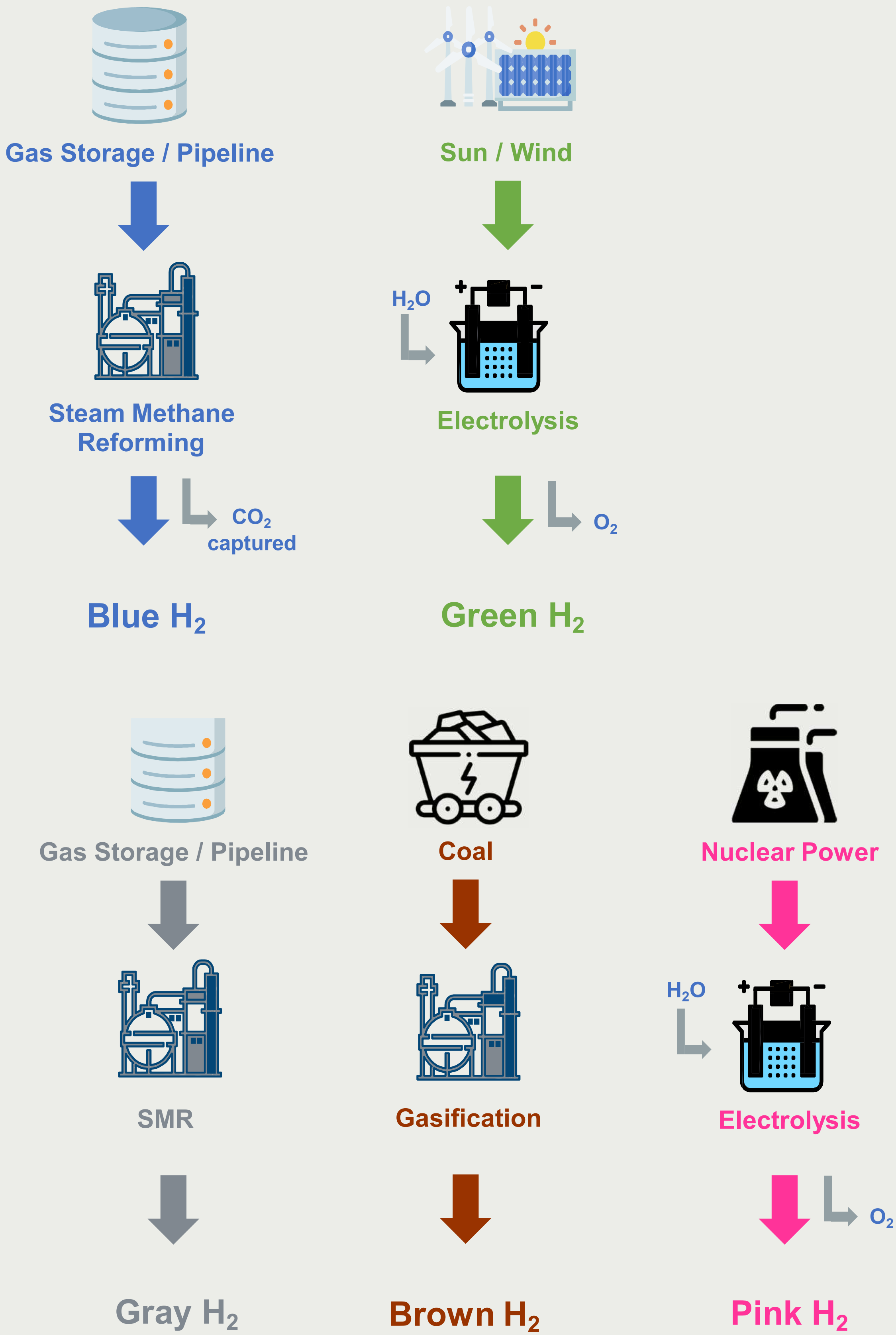
Hydrogen – General Facts



Hydrogen is the most abundant element in the universe. On Earth, hydrogen is abundant in the form of water & gas in the atmosphere.

- Melting Point: 13.81 K (-259.34°C or -434.81°F)
- Boiling Point: 20.28 K (-252.87°C or -423.17°F)
- Density: **0.00008988** grams per cubic centimetre
- Phase at Room Temperature: **Gas**
- Element Classification: Non-metal
- Period Number(Periodic Table): 1
- Group Number: 1
- **Hydrogen is colourless and odourless**.
- With the lowest density among all gases. It is a gas at normal temperature and pressure but **condenses to liquid at** -423° Fahrenheit or **-253° Celsius**.
- Hydrogen **combines with other elements to form compounds**, including common ones such as water (H_2O), **ammonia (NH_3),** methane (CH_4), glucose ($C_6H_{12}O_6$), hydrogen peroxide (H_2O_2) and hydrochloric acid (HCl).

Different shades of Hydrogen(Based on their source of Production)



Hydrogen – Priority Production Pathways

Clean H_2 production pathways:

Priority production pathways: Green, Blue

H_2 Source input		Additional inputs	Process	CCS required? (*neg. emissions)	Reason for prioritization / de-prioritization
Natural Gas	+	Power[1] + water	Steam methane reforming (SMR)	+ CCS	Commercially available and deployed in pilots/few commercial plants (<5); commonly employed with only 60 % capture rate today; higher capture rates more expensive
		Power[1] (heat produced in reformer) + water	Autothermal reforming (ATR)	+ CCS	Commercially available and deployed in pilots; typically larger plant scale, high CO_2 recovery rates & lower CCS costs due to concentrated CO_2
		Power[1] + oxygen (no combustion)	Chemical looping	+ CCS	Low TRL (~100kW); no investment from industry
		Power[1] + oxygen	Partial oxidation (POX)	+ CCS	Similar to ATR, commercially available, high CO_2 capture & lower CCS costs, more flexible on feedstock, lower purity hydrogen product
		Power[1] (no oxygen)	Pyrolysis (methane splitting)		Some promising technology at lab/pilot scale; lower TRL; no CO_2 emissions during process; option to sell by-product 'carbon-black'
Liquid hydro-carbons	+	Power[1] + oxygen	Partial oxidation	+ CCS	Upgrading of residual refinery hydrocarbons to hydrogen. Overall smaller volumes with declining role towards mid-century
Coal	+	Power[1] + oxygen + water (partial combustion)	Coal gasification	+ CCS	Lower process efficiency than SMR; higher carbon emissions per kg hydrogen therefore CCS more expensive
Biomass	+	Power (no oxygen)	Pyrolysis	+ CCS*	Constrained by limited sustainable, low-lifecycle carbon bio-resources
		Power + oxygen + water (partial combustion)	Biomass gasification	+ CCS*	Complex processing, more expensive than alternative routes (especially given high biomass collection costs), with low TRL
		Microorganisms (no oxygen)	Bio-chemical		Biomass has lowest hydrogen to carbon ratio from all feedstocks, hence highest CO_2/H_2 emissions
Biogas	+	Power + water	Biomethane reforming	+ CCS*	However combined with CCS could create "negative emissions" – may have a long-term local role where sustainable biomass available
Water	+	Power	Electrolysis		Declining costs of renewable power, and equipment costs decline with scale – 'zero-carbon hydrogen' feasible
		Nuclear power	Thermochemical water splitting		Low TRL (lab-scale), large advancements in tech required, high cost uncertainty
		Solar power	Solar-chemical water splitting		

- **Why Green Hydrogen?** - **Decarbonising the planet** is one of the **goals that countries around the world** have set for 2050. To achieve this, decarbonising the production of an element like hydrogen, giving rise to green hydrogen
- **100 % sustainable**: Green hydrogen **does not emit polluting gases** either during combustion or during production.
- **Storable:** Hydrogen is easy to store, which allows it to be **used subsequently** for other purposes and at times other than immediately after its production.
- **Versatile:** Green hydrogen can be **transformed into electricity, energy carriers like methanol, ammonia or synthetic gas** and used for domestic, commercial, industrial or mobility purposes.
- **Flexibility:** It can increase **system flexibility, particularly through seasonal storage**, helping to integrate higher shares of solar and wind power.
- **Transportable:** It can be mixed with natural gas at ratios of up to 20 % and travel through the **same gas pipes and infrastructure** - increasing this percentage would require changing different elements in the existing gas networks to make them compatible.

Hydrogen –Pathways for India

For India, full benefits of hydrogen and fuel cell technologies play out when deployed at scale and across multiple applications

2020-2022: Immediate next steps

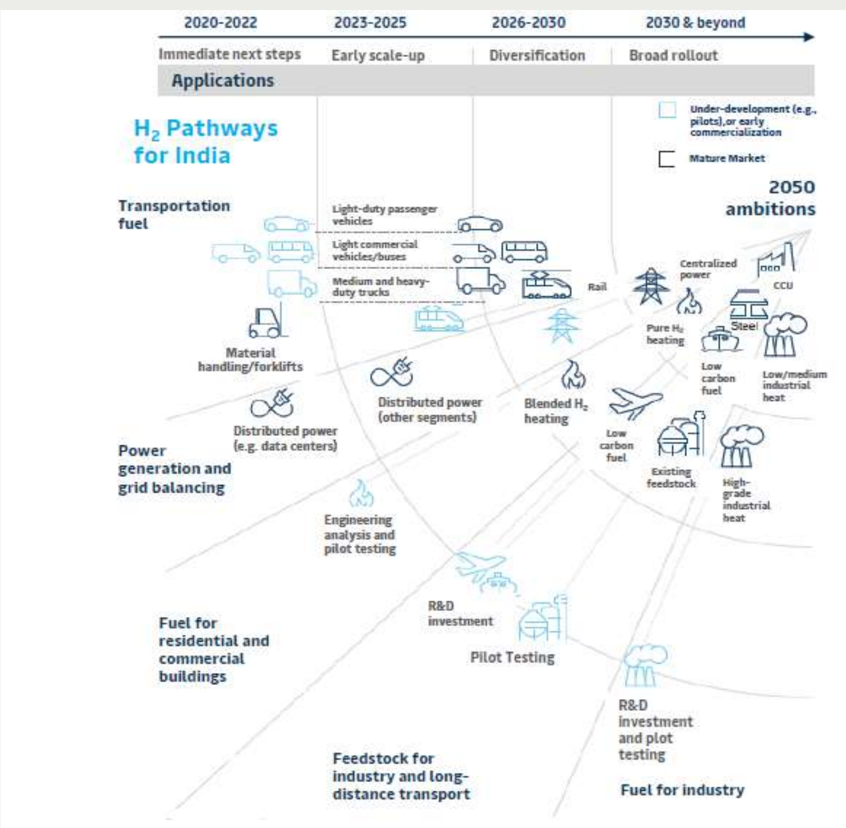
In the first two three years, the aim is to establish dependable and technology-neutral decarbonization goals in a greater number of states in the country and at the central level produce comprehensive guide which will serve input to regulatory & policy dynamics.

2023-2025: Early scale-up

By 2025, large-scale hydrogen production in the country is anticipated to be developed. This shall be done by bringing the cost down and kicking off scale up applications. Policy incentives in early markets being transitioning from direct support to scalable based mechanisms.

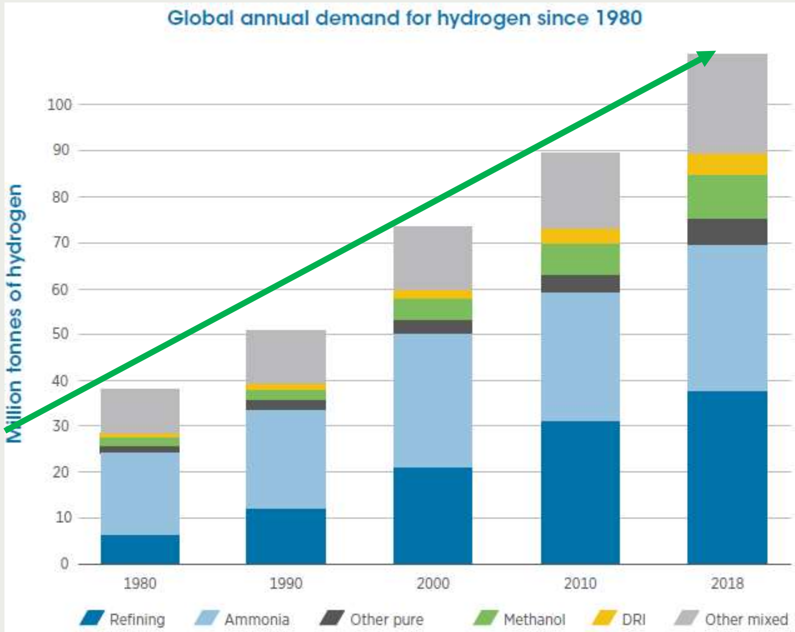
2026-30 & Beyond: Diversification & broad roll-out

The 2026 to 2030 phase is about diversification beyond early adopter segments and early adopter states such as transportation and backup power, and about scaling up infrastructure across the country. After 2030, hydrogen is deployed at scale in India, across regions and industries. Most applications achieve cost parity with fossil fuel alternatives through sufficient pricing of externalities, and public support for market introduction can be phased out



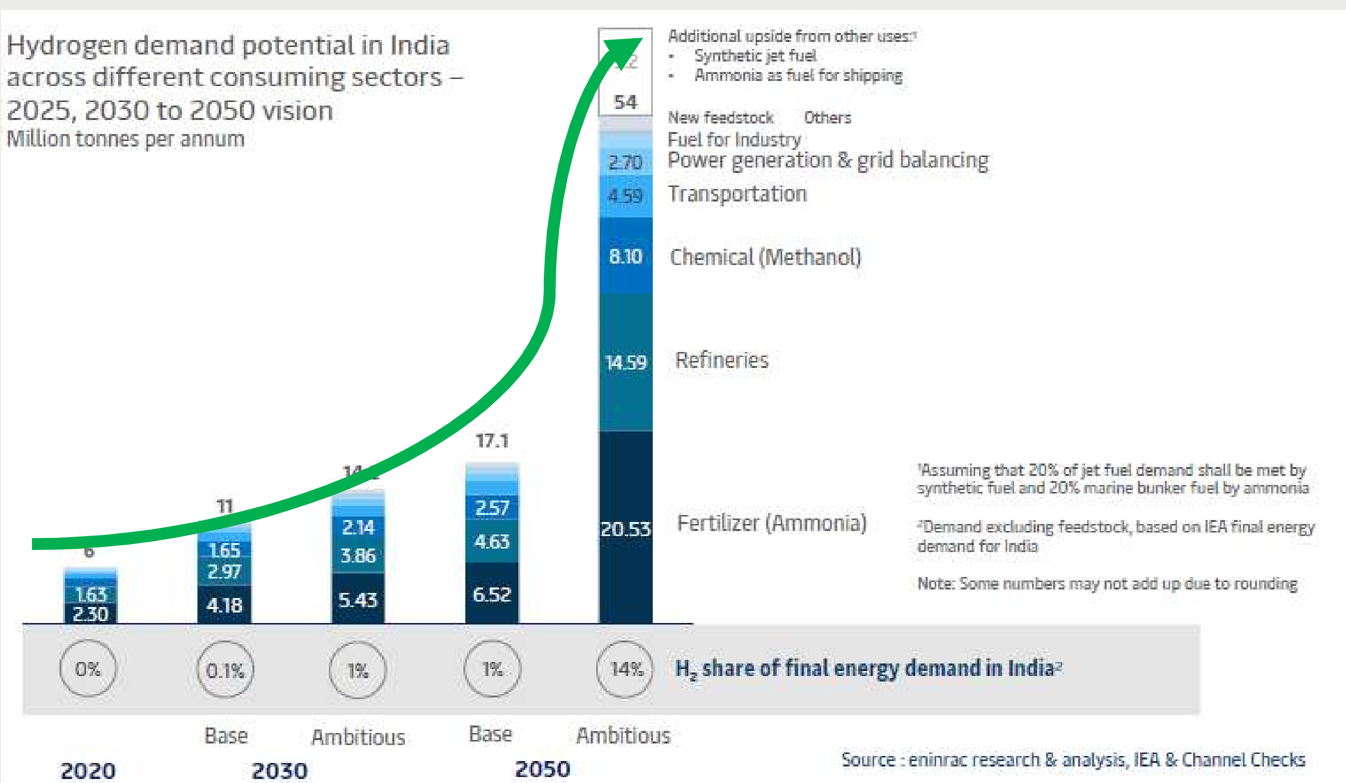
Source: eninrac research & analysis, Channel checks

Hydrogen global Use Trends (1980 – 2018)



Source(s): IEA, 2019

Hydrogen (India) - demand potential across end use application sector –2025, 2030 & 2050 vision



Forecast global hydrogen sector demand in sustainable development# scenario 2019-2070

Note: The **Paris Agreement** sets a collective goal of "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C". While no definition of "well below 2 °C" is provided, the achievement of the goal rest on three pillars: **(i)** global GHG emissions peaking as soon as possible**, (ii)** rapid emissions reductions thereafter, **and (iii)** achievement of a balance between anthropogenic emissions by sources and removals by sinks (i.e. net-zero emissions) in the second-half of this century.

In **the Sustainable Development Scenario**, CO2 emissions from energy and industrial processes peak before 2020 and show a steep decline through the *Outlook* period is clearly consistent with the first two of the Paris Agreement pillars. The long-term temperature outcome beyond the Sustainable Development Scenario in 2040 is dependent on how quickly the third Paris Agreement pillar of net-zero global emissions in the second-half of the century is achieved.

Worldwide; 2020; *ammonia production for shipping fuel, ammonia for industrial use is included in "industry".

Source(s): IEA; ID 760001

- According to the **IEA's sustainable development scenario (which assumes adherence to the Paris Climate Agreement),** pure hydrogen demand could climb to nearly 90 million metric tons by the end of the decade and to over 500 million metric tons by 2070.
- Although the transportation sector is yet only a minor consumer, it is expected to become the largest by mid-century.
- Other potential consumers include the power sector, as hydrogen could be used as a form of energy storage for non dis-patchable renewable electricity.
- As of now, the power sector does not yet have the means for storing excess wind and solar power on days when supply exceeds demand.

Green Hydrogen Clusters based on "early demand" Use

1 Port

Ports[1] as infrastructure hubs for import/export of feedstocks and goods.

Core off-taker:

- **Shipping (Ammonia)**

Often co-located with:

- **Refining & Fertiliser** Import/export of LNG for these industries
- **Steel** Import/export of feedstocks and products
- **Road Transport** Container transport
- **Aviation** Coastal transport hub
- **Forklifts & Ground Operations** Container/goods handling
- **Option for blending** dependant on trade-offs (see Box B) Coincide with LNG storage

2 City

Continental cities serve as non-coastal hub for transport and are often well connected to gas grid infrastructure.

Core off-takers:

- **Aviation**
- **Long-haul trucking & buses**
- **Option for low % H_2 blending** into natural gas grid dependant on trade-offs (see Box B)

Often co-located with:

- **Refining & Ammonia** As large natural gas demand sites commonly close to gas storage/import sites
- **Forklifts & Ground Operations** Heavy transport in mines

3 Refining & Fertiliser

Refineries and fertiliser production are frequently co-located and require large amounts of hydrogen.

Core off-taker:

- **Refining & Fertiliser**

Often co-located with:

- **Ports**
- **Gas storage facilities** – option for low % H_2 blending into natural gas grid dependant on trade-offs (see Box B)

4 Steel

Hydrogen-DRI steel production as major hydrogen off-taker (medium sized steel site requires approximately ~120 kt H_2/year).

Core off-taker:

- **Hydrogen-DRI steel production**

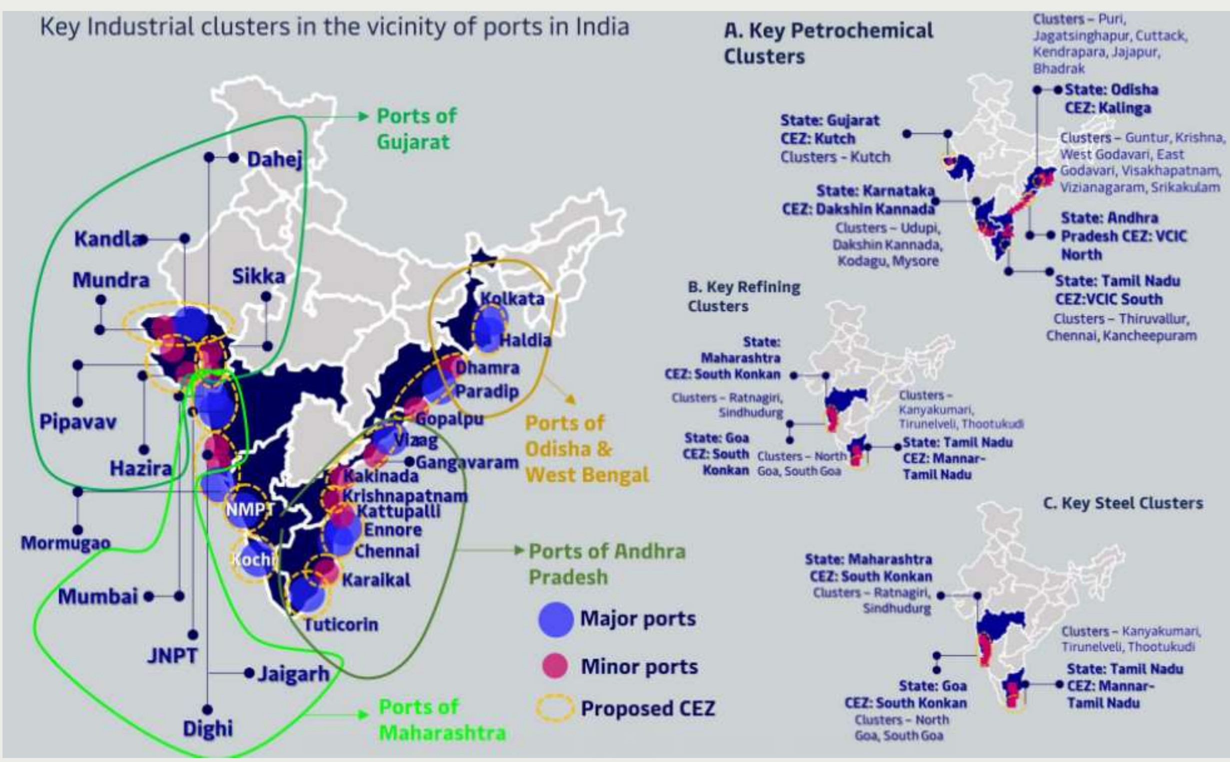
Often co-located with:

- **Ports**

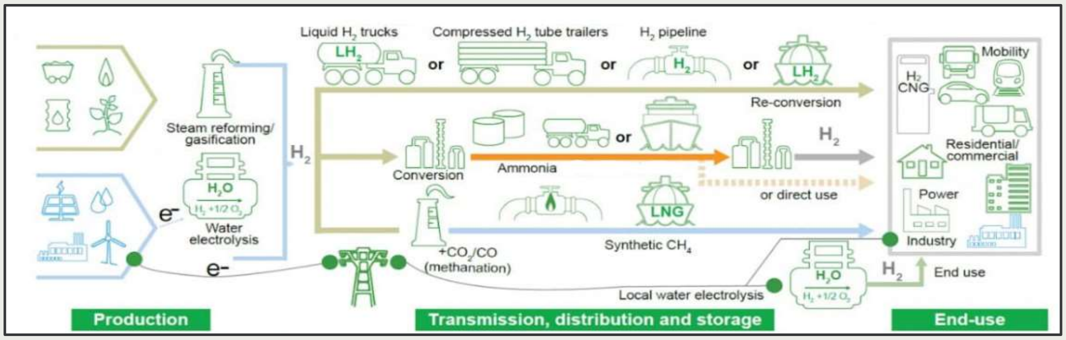
- **Refining, Fertiliser and Steel** offer sufficient off-take to operate on stand-alone basis, but co-location enables shared off-take

- **Road Transport** Dependant on long-term role of hydrogen in road transport & hydrogen refuelling infrastructure network requirements

Setting & Scaling up industrial clusters- in the Vicinity of Ports for hydrogen application



Value chain for Green hydrogen



The green hydrogen production value chain can be divided into **five primary segments**:

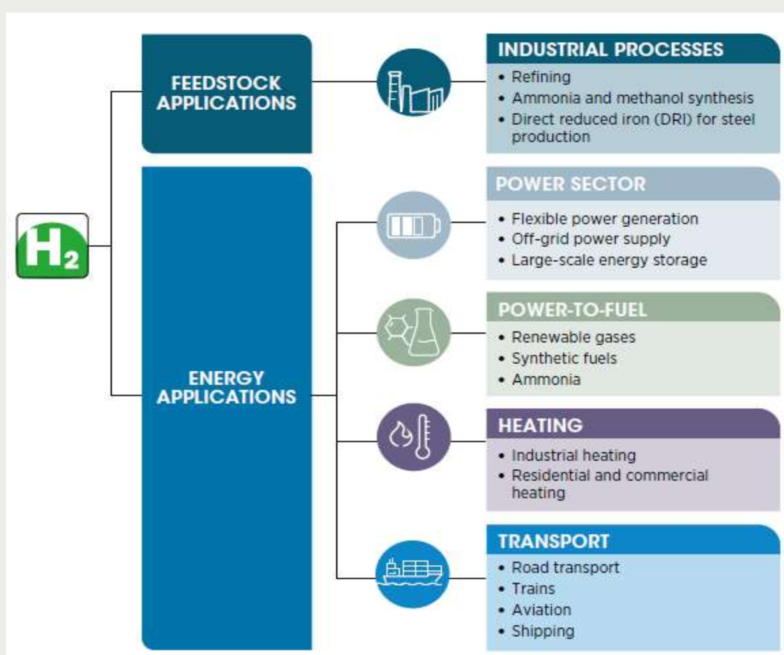
- Process input generation
- Green hydrogen production
- Conversion, including compression and storage
- Transportation, including vessels and pipeline
- Reconversion to gaseous hydrogen as applicable

Green hydrogen can be transported as

- Compressed hydrogen (C-H2)

- Liquefied hydrogen (L-H2)

- Ammonia (NH3)



Key participants in the Hydrogen value chain

Role

Hydrogen production

- Design & manufacture of hydrogen energy systems for clean fuel production & energy storage.
- Development of new technologies for production of hydrogen.
- Development of materials that facilitate the reduction of hydrogen production cost.
- Development & manufacture of electrolysis equipment and hydrogen storage solutions.

Examples:
Hazer group, Mcphy Energy, ITM Power,
Vision hydrogen, Progressive Energy, Powerhouse energy

Fuel Cell Components

- Manufacture and distribute performance chemicals that enable alternative energy storage and fuel cells.
- Produce and sell rare earth luminescent materials.
- Engage in the R&D, Processing, Production and sales of precious metal materials.
- Design, manufacture and distribute flow plates for mass production of fuel cells and heat exchangers.

Examples:
Sino-Platinum metals, Impala Platinum Holdings, Hexagon Composit, Kolon Industries

Fuel Cell Manufacturers

- Development of hydrogen fuel cell stacks and systems.
- Development, manufacture, sales and servicing of hydrogen fuel cell power systems.
- Design, manufacture and installation of stationary fuel cell power plants.
- Operation and maintenance of fuel cell power plants.

Examples:
Ballard Power Systems, Proton Power System, Bloom energy, Ceres Power holding, Powercell Sweden

Major influences on portions of the hydrogen supply chain

Supply chain portion	Supply chain influences
Production (Electrolyser)	• Size of electrolyser needs to be considered to ensure efficient utilisation • Modular technologies likely to prevail over larger bespoke products
Electrolyser cost	• installation and maintenance • scale economies, economies of manufacturing
Electricity Source (feedstock for production)	• The need to ensure a high/higher electrolyser utilisation level would accordingly drive the energy requirements and costs;
Storage, transport and liquefaction	• Transport can be via road, rail or pipeline as gas, liquid or ammonia • Liquefaction capital, OPEX and losses in isolation
Water utilisation	• Water supply logistics vary depending upon scale and location • Use of water entitlements or potable water unlikely to be required given limited marginal cost impact of desalinated or treated water even at small scale • Oxygen by-product is utilised in water treatment reducing costs

Cost of hydrogen storage comparison (2019 vs. 2050)

Storage type: Geological / Tanks — Forecast period: 2019 / Future (c. 2050)

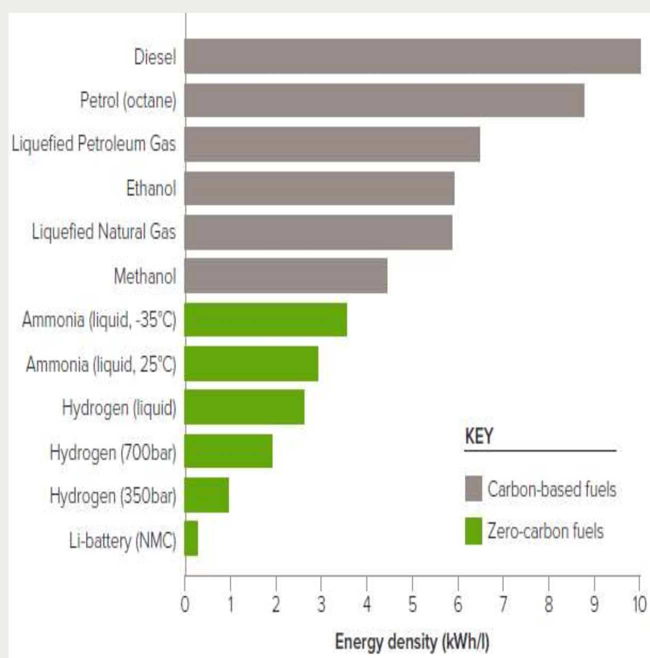
	Storage option	Capacity (t H_2)	Cost of storage ($/kg)	TRL	Example applications
Gaseous state	Salt caverns	300 – 10,000	0.23 / 0.11	9	Large volume storage, medium term (weeks-months)
	Rock caverns	300 – 2,500	0.71 / 0.23	2 - 3	Lage volume storage, medium term (weeks-months)
	Depleted gas fields	300 – 100,000	1.90 / 1.07	2 - 3	Lage volume storage, long term (seasonal)
	Pressurized containers	0.005 – 1.1	0.19 / 0.17	9	Pipelines, short-distance trucking
Liquid state	Liquid hydrogen	0.0002 – 0.2	4.57 / 0.95	7 - 9	Long-distance trucking
	Ammonia	0.001 – 10,000	2.83 / 0.87	9	Long-distance shipping
	LOHCs	0.0002 – 4,500	4.50 / 2.86	7 - 9	Long-distance shipping
Solid state	Metal hydrides	0.0001 – 0.002	Not evaluated	7 - 9	Trucking

Source(s): IEA2019, Future of hydrogen; Bloomberg(2019), Hydrogen – the economics of change

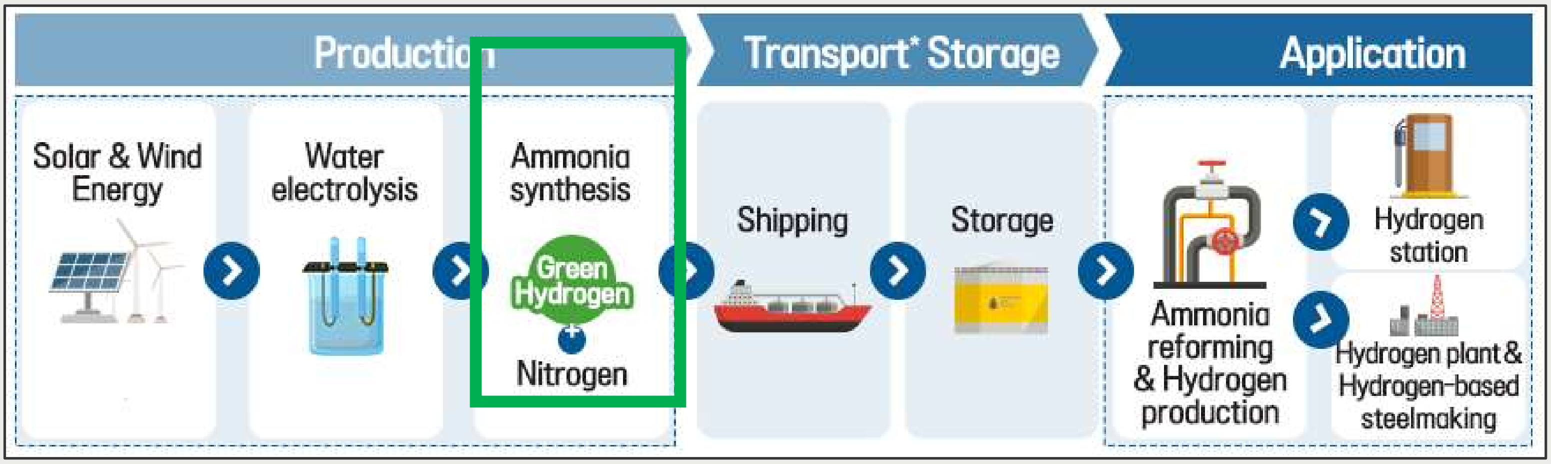
Challenges of hydrogen as carrier

- **Requires very low temperature (about –250 °C) - Compression**
- **High energy requirement for cooling/liquefaction**
- Demands cost reduction for liquefaction
- **Liquefaction currently consumes about 45% of the energy brought by H_2**
- **Difficult for long-term storage**
- Requires boil-off control[boil-off losses that occur with every day of storage]
- **Risk of leakage.** H2 is **highly flammable and explosive**, escapes easily, and has a relatively low density.
- **Not perceptible with human senses** → **Sensors**
- **Transportation of hydrogen** via **pipeline** requires **high initial capital costs** for their construction. Moreover, there are some outstanding technical concerns related to retrofitting existing pipelines for hydrogen transport, including the potential for hydrogen to embrittle the steel.
- Relatively **low volumetric energy density** compared with ammonia, which **limits the amount of hydrogen per ship**
- H2 reacts with many metals, causing them to become brittle.

Volumetric energy density of a range of fuel options



Value chain for Green hydrogen with green ammonia as energy storage



Green ammonia produced through hydrogen generated by electrolysis and then via the Haber-Bosch process by reacting hydrogen and nitrogen with an iron catalyser.

Key merits as ammonia(NH3) carrier:

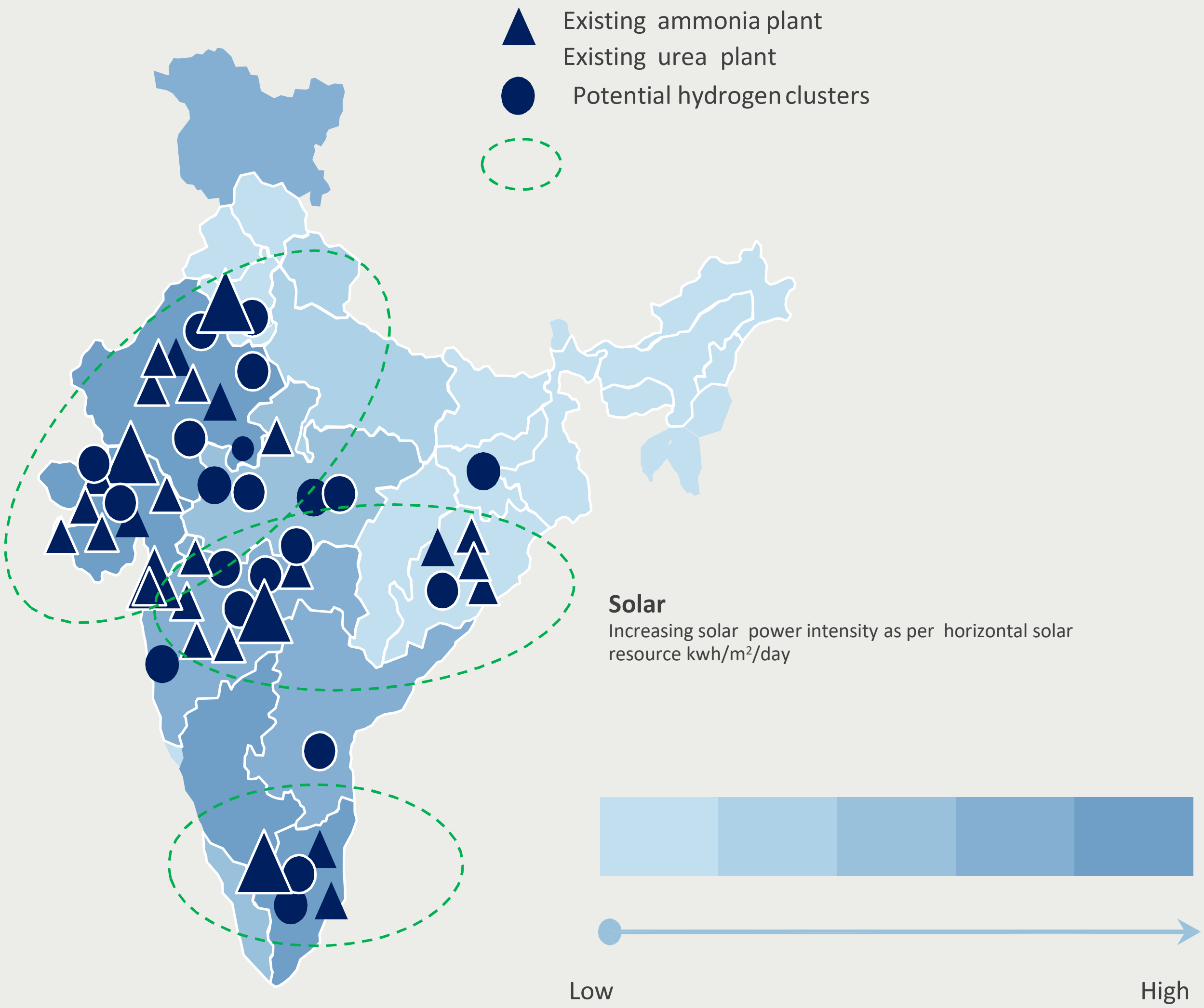
- High hydrogen content (18% by mass), **ease of liquefaction** and similar physical properties LPG providing an **opportunity to use existing storage, transport and terminal equipment**.
- Ammonia also has a long history of large-scale, **cost optimised industrial production** and its **global use as a fertiliser, chemical raw material and refrigerant**.
- already **transported over large distances with good economics.**
- Ammonia* is also **less reactive than hydrogen**, and burns at a lower temperature with reduced flame speed and a narrow flammability range.
- **At room temperature and atmospheric pressure, ammonia is a colourless, pungent gas**. To store in bulk, it requires liquefaction either by compression to 10 times atmospheric pressure or chilling to -33°C.

Note:

(i) Energy efficiency losses vary from about 12% when converting H2 to ammonia, to more than 20% when converting it to methanol or binding it to a carrier, and up to about 35% when converting it to a synthetic hydrocarbon.

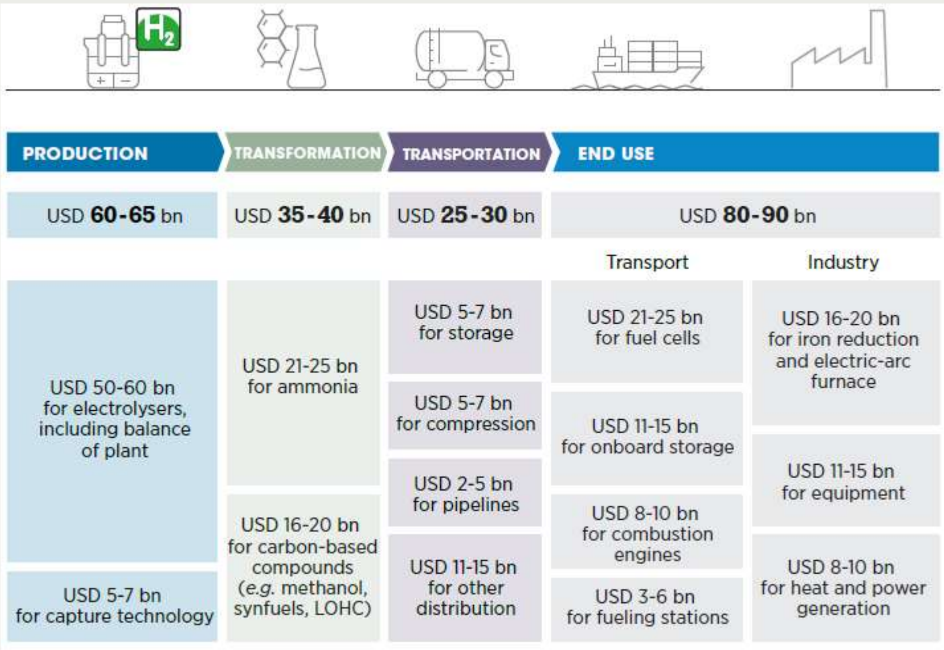
(ii) *Ammonia firing also provides a flame stability challenge, although less so than for hydrogen, with NOx abatement remaining the key challenge. However, NOx abatement with well-proven selective catalytic reduction systems is already successfully used in most stationary NOx sources like power stations in several countries, and would be adequate to tackle this issue.

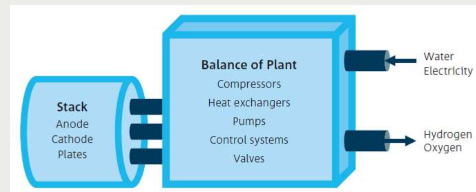
Solar irradiation intensity, existing ammonia and urea plants and potential hydrogen clusters in future for India



Source : eninrac research & analysis and Channel Checks, 2021

Estimated market potential for hydrogen equipment and components, 2050





Source: Ludwig *et al.* (2021). **Note:** LOHC = Liquid organic hydrogen carrier.

Cost estimates for Electrolyser (Alkaline & PEM)

- The first level is a single **cell unit**.
  - Core of the electrolyser where the main electrochemical process takes place.
  - Includes the catalyst coated membrane where the catalyst layers are coated directly as electrodes onto the membrane for the PEM type and the electrodes and diaphragms for the alkaline type, plus the manufacturing of these components which can represent a large share of the costs.
- The second level within **stack** costs.
  - Includes the **cells plus the PTLs, bipolar plates, end plates** and other small parts such as spacers, seals, frames, bolts and others.
  - This level usually represents about **40%-50% of the total**.
- The third level is the **system** costs.
  - Scope is all the **balance of plant components and peripherals** responsible for operating the electrolyser, but excluding any component responsible for further gas compression and storage.
  - Major components for the balance of plant cost models typically include rectifier, water purification unit, hydrogen gas processing (compression and storage) and cooling components.
  - These items can constitute **50%-60% of the total cost**.
  - Today, the **main contributor to system costs** is still the stack, which **represents 40%-50% of the total**, for both **alkaline and PEM electrolysers**.

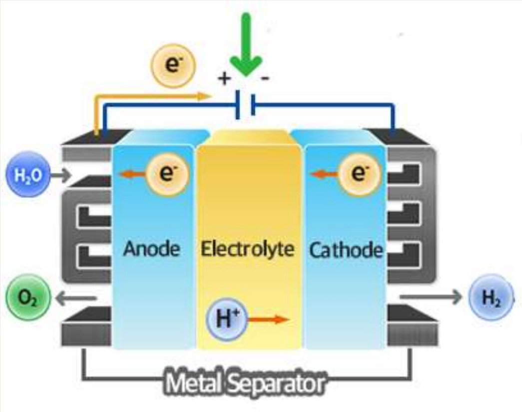
Types of Electrolyzer for extraction of hydrogen

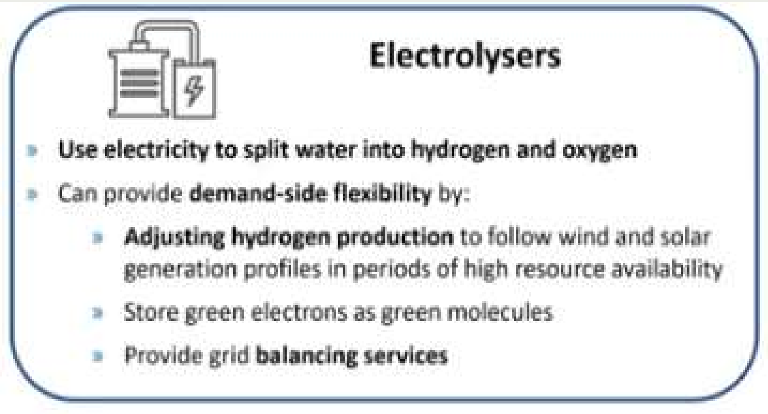
i. Alkaline Water Electrolyzer

ii. PEM (Polymer Electrolyte Membrane)

iii. Solid Oxide Electrolyzer Cells (SOEC)

iv. Anion Exchange Membrane





S#	Type of Electrolysis	Efficiency	Purity of H2 gas	Stack Lifetime (Thousand hour)	Capital Cost (USD/kW)	Remarks
1	Alkaline Electrolysers(AE)	70%	99.50%	60-90	1200-2000	**-Mkt Share: 61%** Use chemicals like potassium or sodium hydroxide which are available in the market. Operates at temp b/w 60 deg Celsius and 80 deg Celsius
2	Polymer Electrolyte Membrane(PEM)	58%	100.00%	20-60	2000-2400	**-Mkt Share: 31%** -Compact and have a lower area footprint compared to alkaline electrolysers. -Can be operated at low temperatures (20–80 deg Celsius) to produce ultra-pure hydrogen and oxygen. -Better equipped to handle the variation in renewable energy from solar and wind -Need proprietary components like specialised membranes and access to critical minerals like iridium for developing the manufacturing ecosystem(India does not have access to these components and critical minerals).
3	Solid Oxide Electrolyser(SOE)	55%	99.90%	<10	>2200	-Mkt Share: 8% -Operates at high pressure and temp (500–850 deg Celsius) in the presence of metals as the catalyst.
4	Anion Exchange Membrane(AEM)	69%	99.99%	>5	-	-Process is still at the R&D -Upcoming technology that consumes less electricity

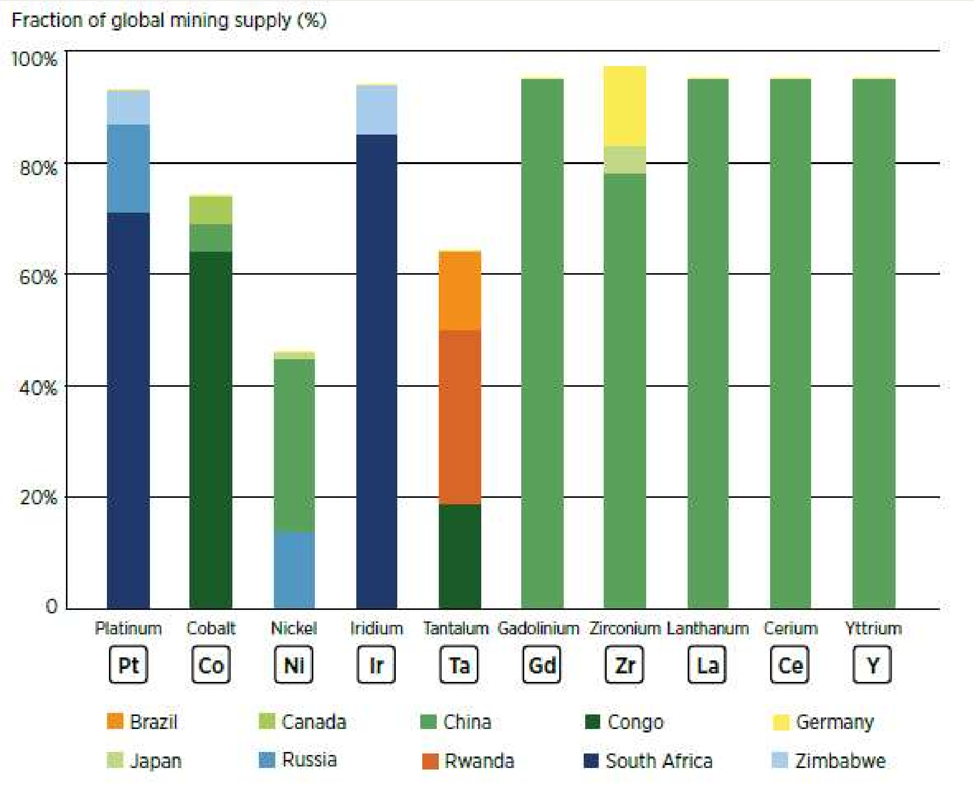
Electrolyser's Present Status

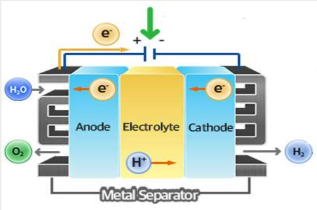
	Alkaline Electrolyser	PEM Electrolyser	SOEC Electrolyser
Commercial status	Mature	Commercial, fast growth	Demonstration plants
Electrolyser electrical efficiency kWh/kg hydrogen	Today: 48 – 53 2030: 47 – 51 Long term: 42 – 48	Today: 56 – 59 2030: 49 – 53 Long term: 45 – 50	Today: 41 – 45 2030: 40 – 43 Long term: 37 – 43
Operating temperature (°C)	60 – 80	50 – 80	650-1,000
Plant footprint m² / kW	0.095	0.048	-
Characteristics	• Slower dynamic response[1]	• Faster dynamic response	• Highest efficiency, no cycling[2]
Implications	• Less well suited to **intermittent power supply** (e.g. renewables) – likely to be overcome by innovation for faster ramping and batteries to smooth short term variations.	• Well suited to a **variable electricity supply** (e.g. intermittent renewables) • Suitable for voltage regulation services	• Potentially well suited for **constant base-load H_2 production** in future • Only technology to reverse function and able to work as fuel cell to produce electricity
Stack lifetime (2030)	• 90,000 – 100,000	• 60,000-90,000	• 40,000-60,000
Major producers (non-exhaustive)	• Suzhou Jingli, Thyssenkrupp, Nel	• Siemens, ITM Power, Cummins	• Haldor Topsøe, Ceres, Sunfire

Sources: Bloomberg NEF (2021), 1H2021 Hydrogen Market Outlook

Comparison b/w Alkaline & PEM Electrolyzers	
Alkaline	**PEM**
Most mature technology, having been used in the fertilizer and chlorine industries since the 1920s. **Pros:** Compared to PEM electrolysis, the alkaline method offers key advantages including: 1. It relies on convenient catalysts - **electrolyte solutions are widely available and cheap to produce.** 2. Cheap inputs also mean that a large part of the cost of an alkaline electrolyser is labour - this in turn implies significant economies of scale. 3. Electrolyte solutions are easily exchangeable and have minimal corrosive impact on the electrodes, implying relatively **long useful life of the electrolyser.** 4. Alkaline electrolysis produces highly pure H2 as hydrogen does not easily diffuse in the electrolyte solution. **Cons** 1. **Slower dynamic response; less suited for variable renewable energy (VRE) support.**	**Pros:** 1. higher purity of output compared to alkaline machines. 2. **fast response times, which make PEM electrolysers suitable to provide grid balancing services and allow PEMs to better deal with the volatility of renewable output (resulting in higher efficiency).** 3. **very small scale can be achieved and installation is simple, making PEM electrolysers easy to bring onsite.** 4. work above capacity for short periods 5. **Compact & have a lower area footprint compared to alkaline electrolysers.** **Cons:** 1. PEM electrolysers are more expensive. 2. PEM electrolysers more expensive because of the materials used, meaning that there are limited economies of scale on large installations. **Platinum and iridium(scarce and emission-intensive metals)** are required. Current global iridium production could support annual deployment of up to 3-7.5 GW a year.

Different types of electrolysers different material requirements.





Source: IRENA 2020a

Comments:

Alkaline electrolysers:

- dominate the market today, rely on materials that are generally deemed uncritical, such as steel and nickel.

Polymer-electrolyte membrane electrolysers and solid-oxide Electrolysers:

- appear to pose more serious problems of critical material dependence. **Platinum and iridium, used in polymer-electrolyte membrane electrolysers**, are two of the most **scarce and emission-intensive metals** in the world. Their supply is also **highly concentrated, with South Africa supplying over 70% of global platinum and over 85% of global iridium** (Figure).
- Currently **no substitutes for iridium are available or foreseen**.
- It is important to note that the **markets for many of these materials are not liquid and are inelastic in the short-term**. This means that a relatively **small change of supply and demand can result in large price fluctuations**. The past 20 years, for instance, have seen prices fluctuate by a factor of four for platinum, a factor of 15 for palladium, and a factor of 70 for iridium.
- Price fluctuations could reverberate through hydrogen supply chains and **affect the overall cost of key pieces of equipment, such as electrolysers, while also affecting the revenues for miners and raw material exporters**.

Key performance indicators for four electrolyser technologies today and in 2050

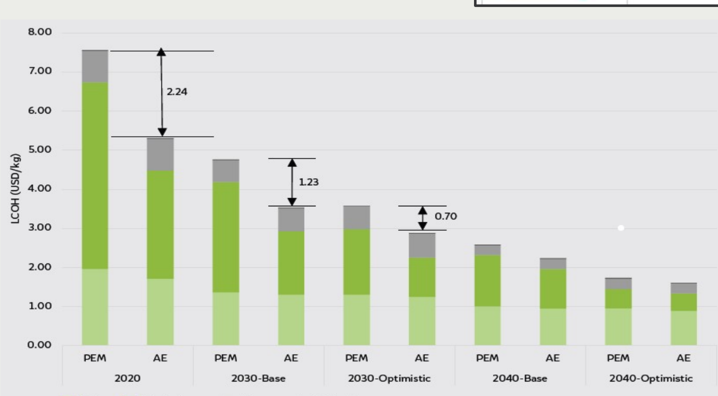
	2020				2050			
	Alkaline	PEM	AEM	SOEC	Alkaline	PEM	AEM	SOEC
Cell pressure [bara]	< 30	< 70	< 35	< 10	> 70	> 70	> 70	> 20
Efficiency (system) [kWh/KgH_2]	50-78	50-83	57-69	45-55	< 45	< 45	< 45	< 40
Lifetime [thousand hours]	60	50-80	> 5	< 20	100	100-120	100	80
Capital costs estimate for large stacks (stack-only, > 1 MW) [USD/kW_{el}]	270	400	-	> 2 000	< 100	< 100	< 100	< 200
Capital cost range estimate for the entire system, >10 MW [USD/kW_{el}]	500-1000	700-1400	-	-	< 200	< 200	< 200	< 300

Source: IRENA, Green hydrogen cost reduction

Analysis:

- Lifetime of electrolysers will increase with technological advancements.
- Electrolysers capital cost requirements is projected to half in future.
- At present scenario, use of Alkaline electrolysers is recommended but with technology innovation, PEM have potential to be preferred in coming future.
- At present Hydrogen obtained from the PEM electrolyser is expensive than alkaline electrolyser, but the difference is expected to decrease in the future

Company	Head Quarter	Electrolyser Manufacturing capacity,	Manufacturing expansion plan	Key Tie-ups,Partnerships with
ITM POWER	UK	350 MW	1 GW by 2024 & 2 GW in future	Snam, Linde, Chiyoda, Ballard, Scottish Power
McPhy	France	~125 MW	300 MW by 2023 and 1.3 GW by H1-2024	EDF (Hynamics), De Nora, Technip Energies, Chart Ind.
nel	Norway	80 MW	500 MW during 2021 & 2 GW in future	Exelon, Kvaerner, Nikola, First Solar, Iberdrola, Aibel
Green Hydrogen Systems	Denmark	75 MW	Existing facility can be scaled to 1 GW	Orsted, Siemens Gamesa, Skai Energies
SIEMENS energy	Germany	Data not avl.	Data not avl.	Air Liquide, China Power(SPIC) , DEWA
Enapter	Italy	~600 AEM Electrolysers in Italy	100,000 AEM Electrolysers per year in germany	Elektrik Green, Beijing SinoHY, Beijing Shenqian, H2X
PLUG POWER	US	~50 MW	500 MW by 2024	Johnson Matthey, The Southern co., SK Innovation



Cost breakdown categories for solar PV

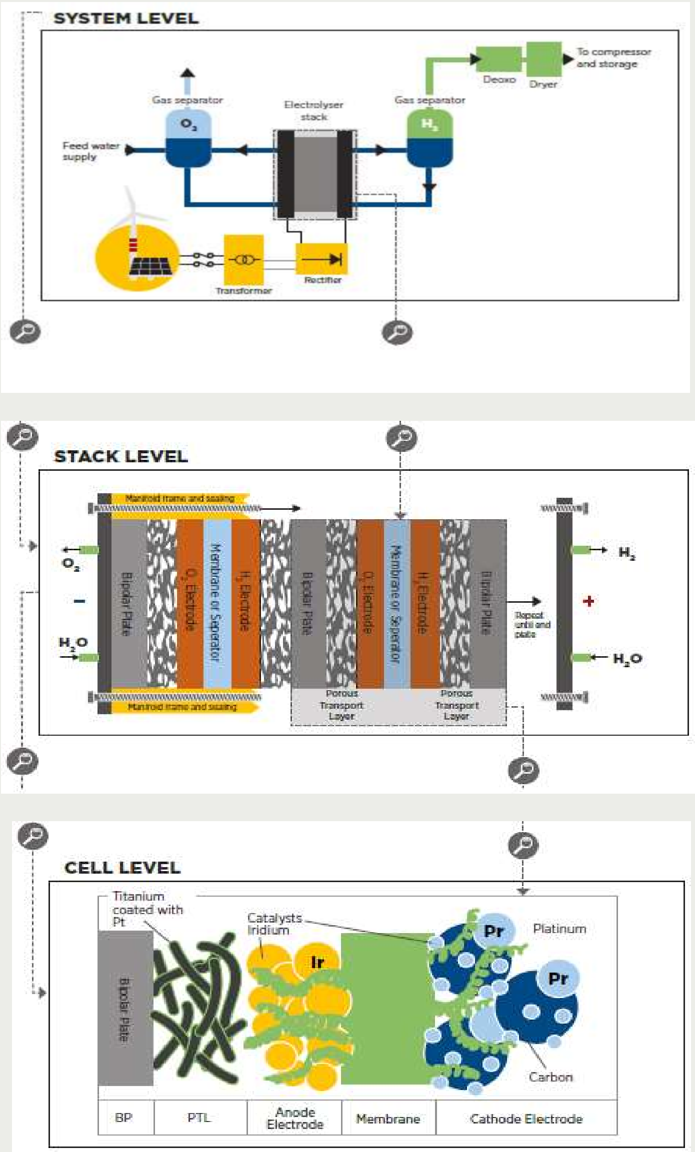
Balance of System(BoS) cost breakdown categories for solar PV	
Category	Description
Non-module hardware	
Cabling	-All direct current (DC) components, such as DC cables, connectors and DC combiner boxes -All AC low voltage components, such as cables, connectors and AC combiner boxes
Racking and mounting	-Complete mounting system including ramming profiles, foundations and all material for assembling. -All material necessary for mounting the inverter and all type of combiner boxes
Safety and security	-Fences -Camera and security system -All equipment fixed installed as theft and/or fire protection
Grid connection	-All medium voltage cables and connectors -Switch gears and control boards -Transformers and/or transformer stations -Substation and housing -Meter(s)
Monitoring and control	-Monitoring system -Meteorological system (e.g., irradiation and temperature sensor) -Supervisory control and data system

Hardware	Installation	Soft costs
Modules	Mechanical installation	Margin
Inverters	Electrical installation	Financing costs
Racking and mounting	Inspection	System design
Grid connection		Permitting
Cabling/wiring		Incentive application
Safety and security		Customer acquisition
Monitoring and control		

Installation	
Mechanical installation (construction)	-Access and internal roads -Preparation for cable routing (e.g., cable trench, cable trunking system) -Installation of mounting/racking s ystem -Installation of solar modules and inverters -Installation of grid connection components -Uploading and transport of components/equipment
Electrical installation	-DC installation (module interconnection and DC cabling) -AC medium voltage installation -Installation o f m onitoring a nd control system -Electrical tests (e.g., DC string measurement)
Inspection (construction supervision)	-Construction supervision -Health and safety inspections

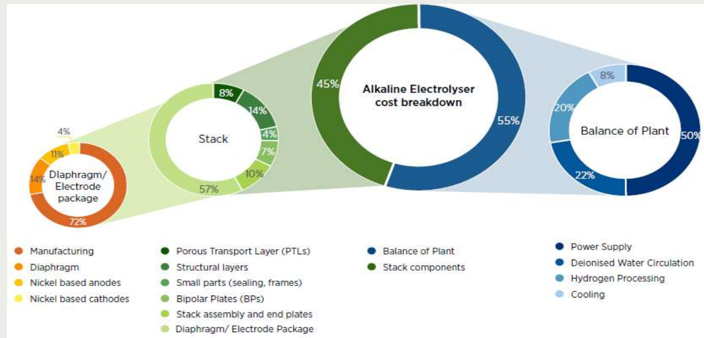
Soft costs	
Incentive application	-All costs related to compliance in order to benefit from support policies
Permitting	-All costs for permits necessary for developing, construction and operation -All costs related to environmental regulations
System design	-Costs for geological surveys or structural analysis -Costs for surveyors -Costs for conceptual and detailed design -Costs for preparation of documentation
Customer acquisition	-Costs for project rights, if any -Any type of provision paid to get project and/or off-take a greements in place
Financing costs	-All financing costs necessary for development and construction of PV system, such as costs for construction finance
Margin	-Margin for EPC company and/or for project developer for development and construction of PV system includes profit, wages, finance, customer service, legal, human resources, rent, office supplies, purchased corporate professional services and vehicle fees

Basic components of water electrolysers at different levels.



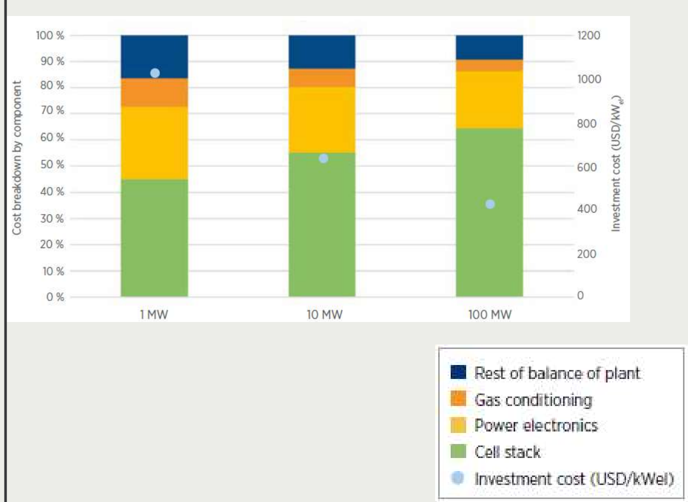
Source: IRENA, Green hydrogen cost reduction

Cost breakdown for 1 MW alkaline electrolyser, moving from full system, to stack, to membrane electrode assembly (MEA).



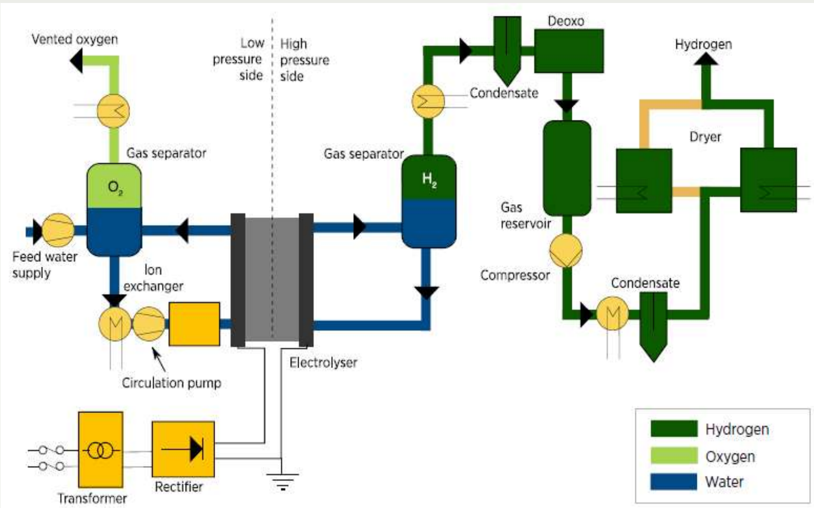
Source: IRENA, Green hydrogen cost reduction

Cost breakdown by major component for alkaline electrolysers based on current costs 2020

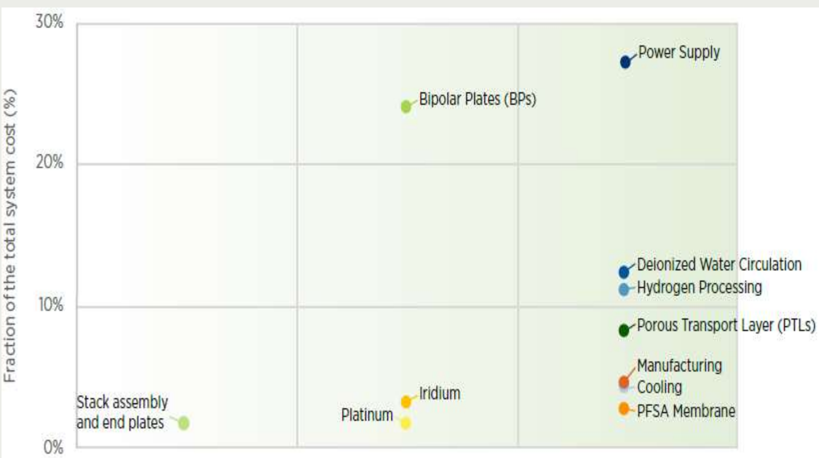


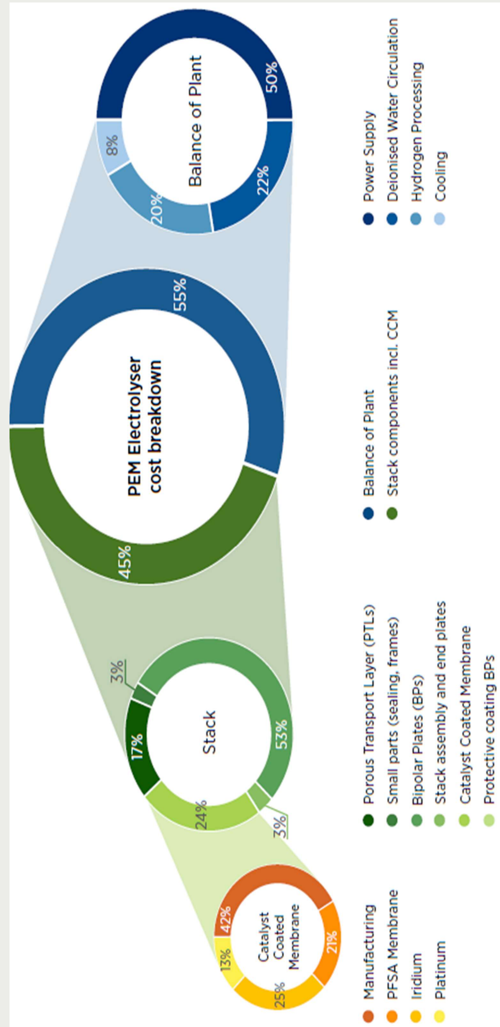
Source: IRENA, Green hydrogen cost reduction

Basic components of system design and balance of plant for a PEM electrolyser.



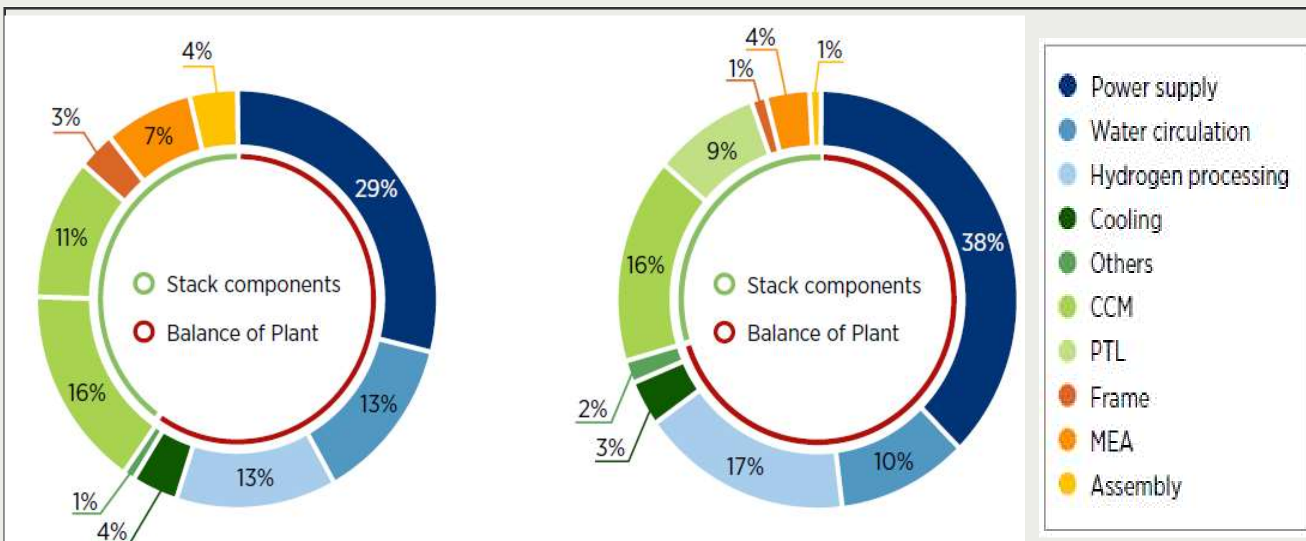
Source: IRENA, Green hydrogen cost reduction





Cost breakdown for a 1 MW PEM electrolyser, moving from full system, to stack, to CCM(Catalyst Coated Membrane)

Cost breakdown for PEM electrolysers for (a) 10 MW/year; (b) 1 GW/year production scale.

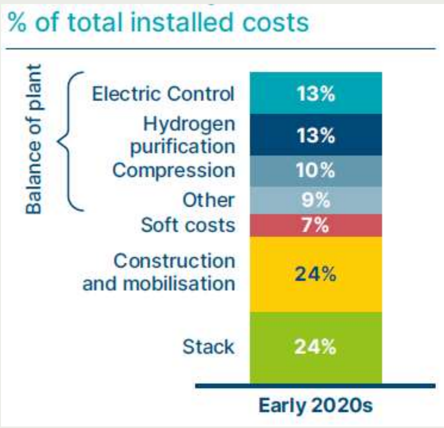


Source: IRENA, Green hydrogen cost reduction

Cost breakdown of 20 MW alkaline electrolyser installation*

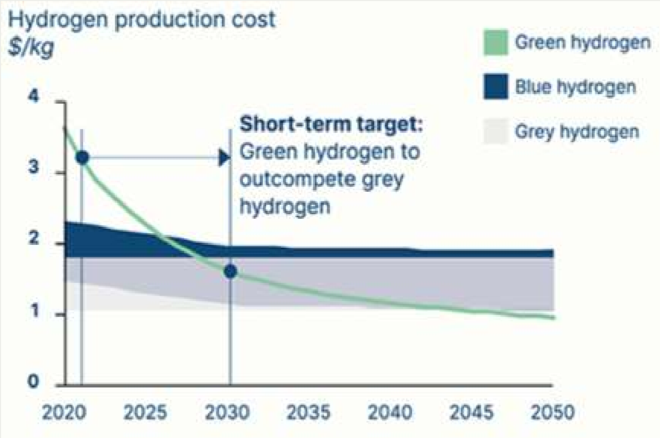
*Total cost of project $780/Kw, Soft cost include project design, management & overhead

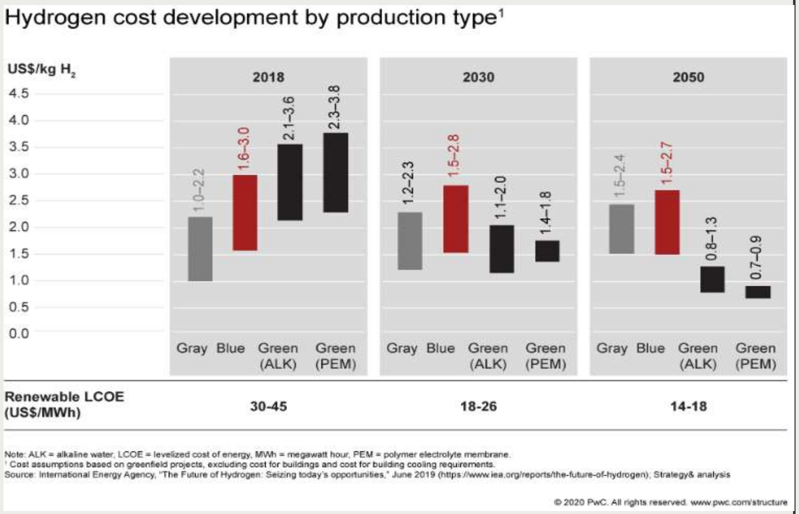
- Balance of plant is significant cost driver (ca.~50%) in a typical project.
- Project and regional variation of soft costs, construction & mobilisation, balance of plants costs
- All cost elements anticipated to decline with increasing electrolyser deployment. Split of cost drivers expected to remain approximately constant.



Source: BloombergNEF(2021)

Green hydrogen - Competitive compared to grey & blue hydrogen





Sources: Making the Hydrogen Economy Possible

Green hydrogen to break even with gray hydrogen in India by 2030 –India might see a break-even for green and grey hydrogen as early as 2030 driven by primarily three factors –

- Falling Capex for electrolyser
- LCOE for renewable power generation is on continuous decline
- Globally larger capacity utilization for RE based H2projects are witnessed

Cost of green hydrogen & Key drivers for cost competitiveness(Present Status)

- Green hydrogen is not yet broadly cost competitive as compared to the conventional fuels it would substitute.
  - This cost disparity should diminish as the cost of renewable energy continues to decline and/or green hydrogen projects are developed in such a way as to consume renewable energy that would otherwise be curtailed.
  - Transportation, conversion, infrastructure and end-use upgrade costs will continue to be meaningful drivers of the cost structure of green hydrogen vs. alternative fuels
- Other forms of hydrogen (e.g., blue hydrogen) are currently less expensive than green hydrogen, particularly in the absence of carbon pricing or other mechanisms used to account for emissions.
- The **cost competitiveness** of green hydrogen should increase as the industry grows, driving improvements in the underlying electrolyser technology in conjunction with cost improvements resulting from manufacturing scale and efficiency.
- Electrolyser stack costs currently comprise ~40% – 50% of the total capital costs while the cost of electricity can represent in excess of ~50% of the levelized cost of green hydrogen—the cost trajectory of renewable energy and availability of excess/low-cost renewables generation will be key drivers of the cost competitiveness of green hydrogen.
- Policy action (e.g., carbon prices or incentives) should also influence the relative cost of green hydrogen as compared to fossil fuel alternatives.
- The establishment of supply and demand centers, and connecting infrastructure, whether by policy makers or Industry leaders, will accelerate the adoption of green hydrogen by reducing switching costs and generating economies of scale.
- The future cost competitiveness of green hydrogen will also depend on the interplay between end use and proximity of production to the end user, which in turn informs the transportation, conversion and storage costs associated with a given application.

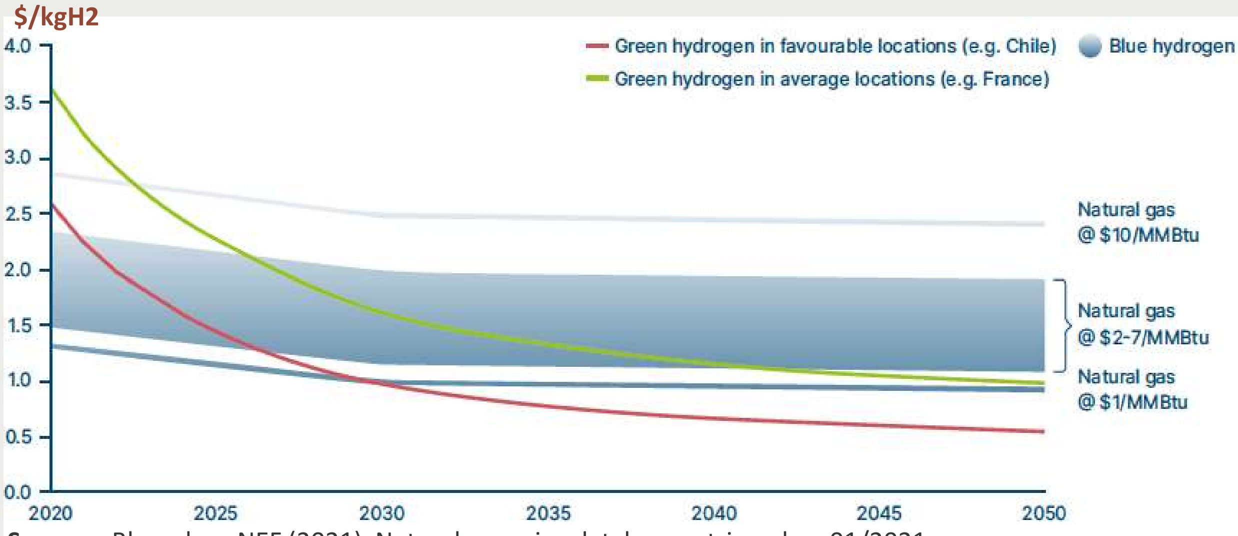
Renewable Energy Production and Location Impact Costs

- Given that the cost of electricity is a key driver of the cost of green hydrogen, the availability of low-cost renewable energy is critical—the optimal locations for green hydrogen production in this regard will be in areas that:
  1. Have the capacity to produce green hydrogen at scale and with abundant low- or zero-cost (i.e., curtailed) renewable energy resources.
  2. Have proximate demand for local green hydrogen (e.g., driven by de-carbonization regulations/incentives) and/or are equipped with efficient transportation infrastructure, thereby avoiding high transportation and/or storage costs

Green Hydrogen Cost (Natural gas vs Green hydrogen)

Cost of hydrogen production from different production routes (Excluding transport & Storage costs)

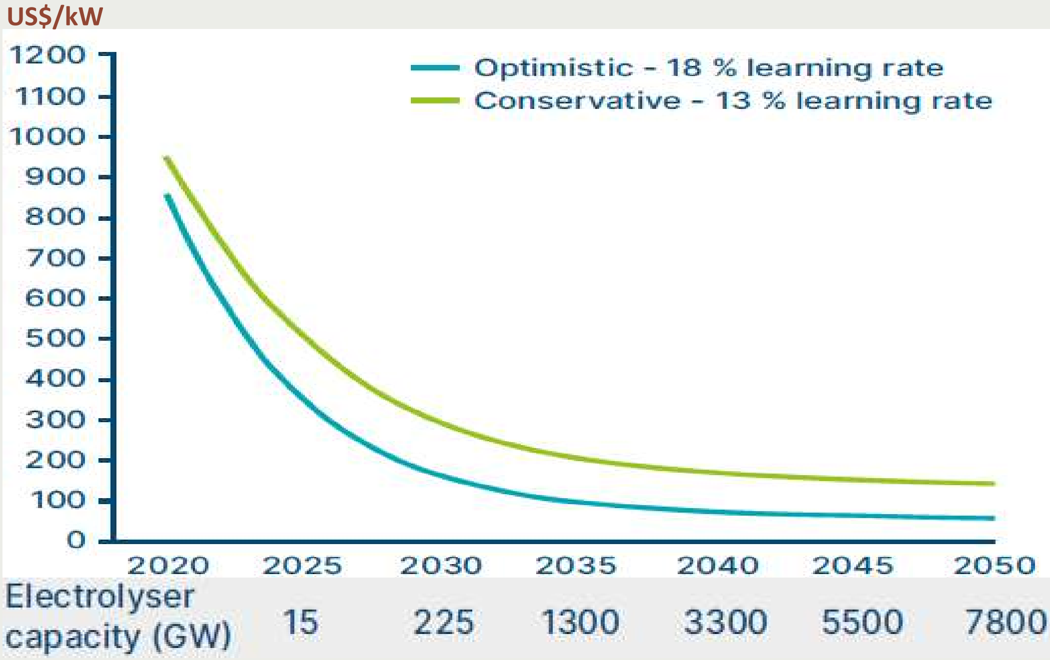
$/kgH2



Sources: BloombergNEF (2021), Natural gas price database retrieved on 01/2021

Fully Installed system CAPEX forecast of large alkaline electrolysis projects

US$/kW



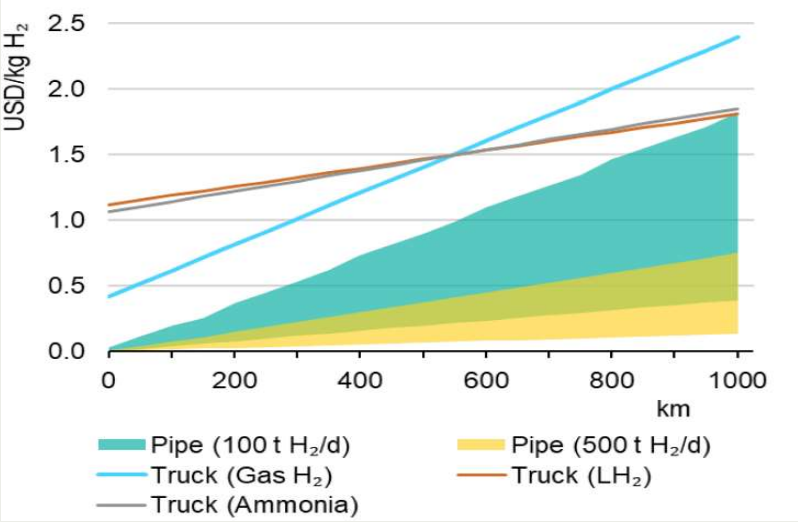
Sources: Bloomberg NEF (2021), Hydrogen economics of production from renewables

Comments:

- Green hydrogen from electrolysis likely to become cheapest clean production route in the long term.
- With technological advancements, Electrolyser CAPEX will reduce & capacity will increase.
- **Green hydrogen production costs** (excluding transport & storage costs) **are expected to fall driven by both**
  - **Falling capital cost of electrolysers**
  - **Continued declines in renewable electricity prices.**

  These are the two main factors for reduction of cost of green hydrogen

Estimated transport costs per unit of hydrogen via different types of transport

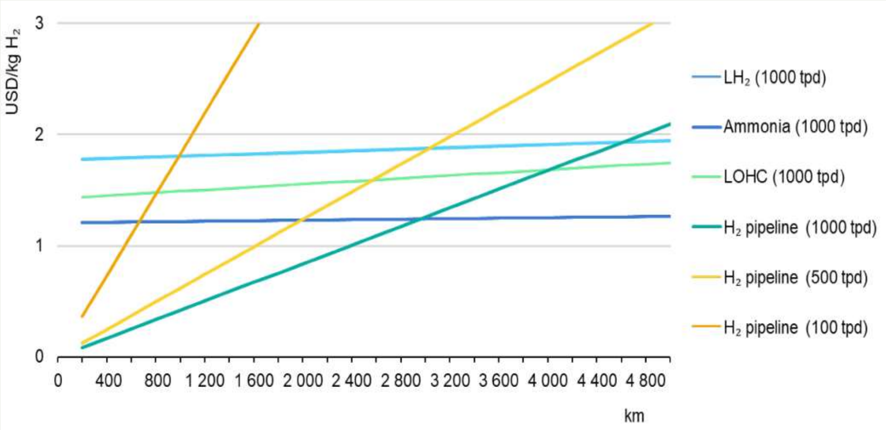


Comments:

- In the graph, the lower limit for pipeline costs corresponds to repurposing existing pipelines, the upper one to building new pipelines.
- Truck transport costs are based on a capacity of 10 t H2/d;
- In the case of liquefied hydrogen and ammonia, they include conversion and reconversion costs.

Sources: Based on FNB (2020), Netzentwicklungsplan 2020; Gas For Climate (2021), European Hydrogen Backbone 2021; Gasunie-Energinet (2021), Pre-feasibility Study for a Danish-German Hydrogen Network

Costs of delivering GH2 by pipeline and LH2, LOHC and ammonia by ship, **2030**



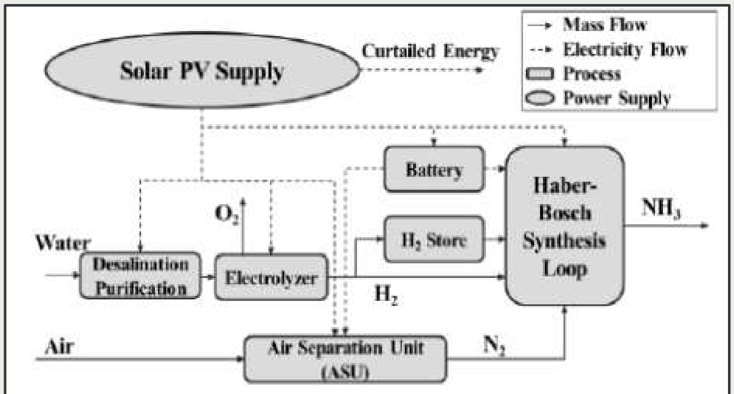
Comments:

- **Hydrogen** is **mostly provided in a gaseous state for end-use applications**, which is difficult to transport except over **short distances via pipeline.**
- Delivering hydrogen in the form of green ammonia has the best cost advantages for export markets that are over 2,800 kilometres from production sites.

Notes: GH2 = gaseous hydrogen. LH2 = liquid hydrogen. LOHC = liquid organic hydrogen carrier. tpd = tonnes per day**. Includes conversion, export terminal, shipping, import terminal and reconversion costs for each carrier system. Storage costs are included in import and export terminal expenses. The pipeline cost assumes construction of a new pipeline.**

Sources: Based on IAE (2016); Baufumé (2013).

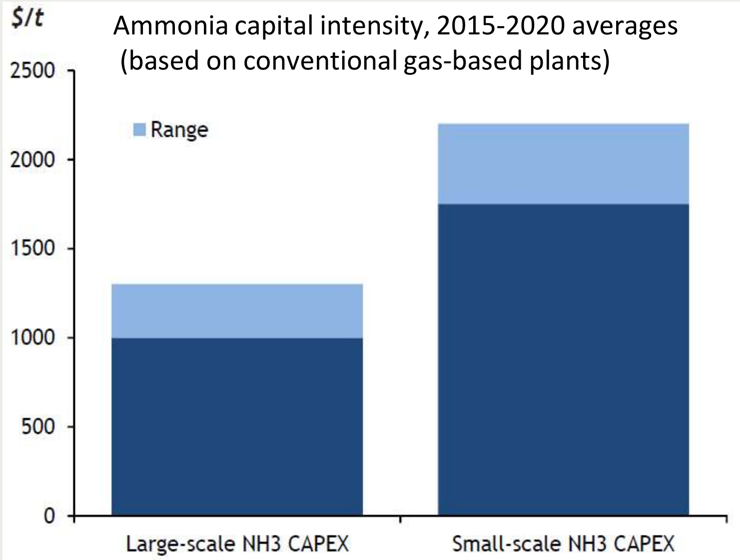
Green Ammonia Synthesis Cost Components



Green ammonia synthesis process

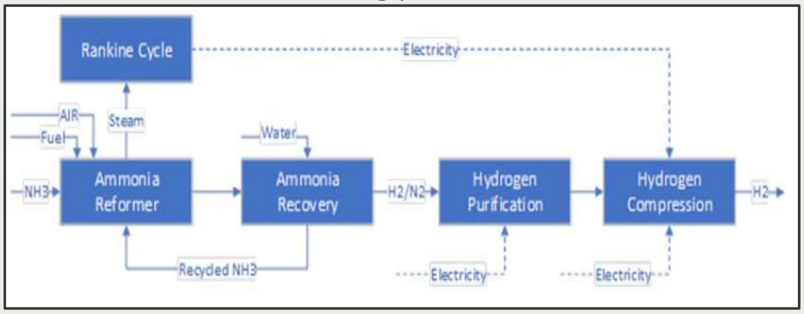
Major Cost Components are:
-Haber-Bosch Synthesis Loop
-H2 Storage Unit
-Air Separation Unit (ASU)
-Battery

Green Ammonia Plant CAPEX



Source: Argus Media

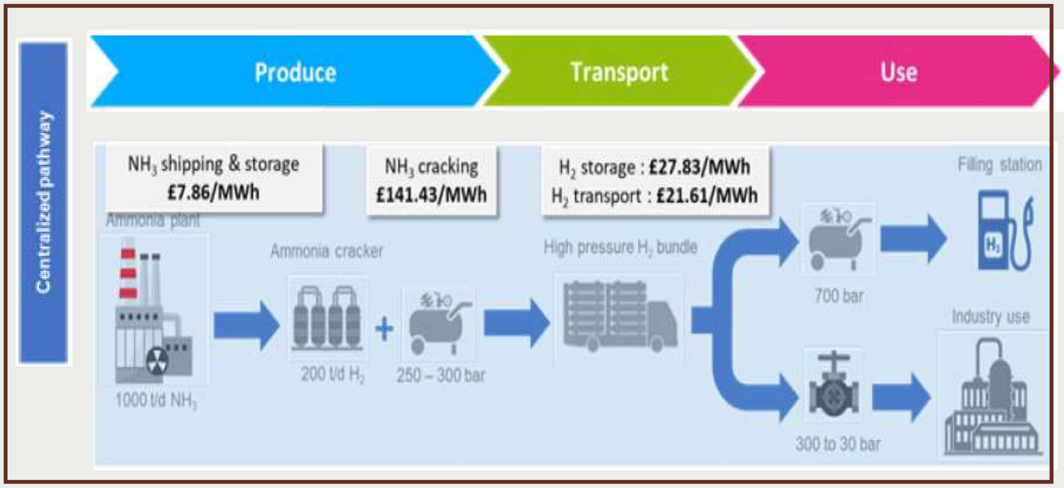
Green Ammonia cracking plant



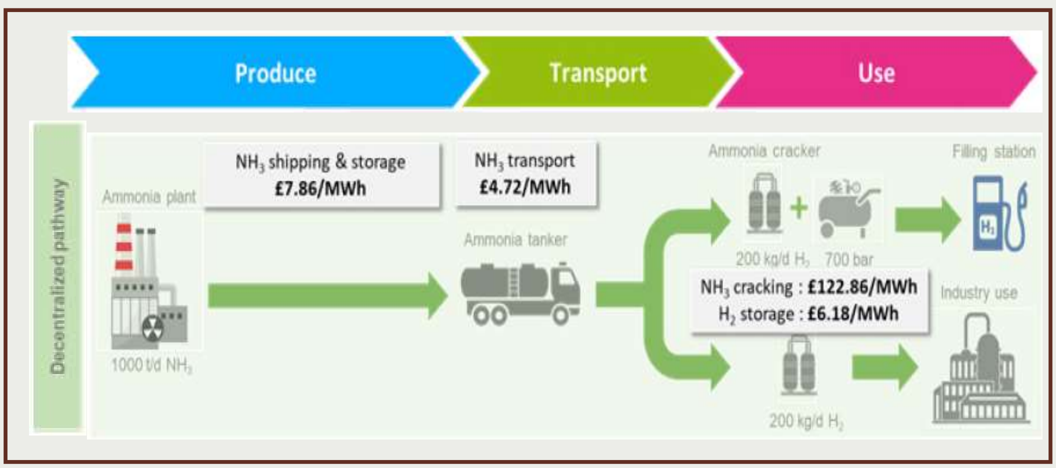
Major Cost Components are:
-Mechanical components
-Control System

- Existing ammonia capacity is largely already utilised, future demand for ammonia will require significant additional supply investment. From a capital cost perspective, economies of scale still favour conventional ammonia plants.
- An important **factor to consider** for **green ammonia project** is the **plant size.** The average size of today's wind and solar power plants could not support a standard Haber-Bosch ammonia plant.
- Therefore, green ammonia project activity focusing on small-scale ammonia production currently implies higher capital intensity compared with conventional plants.
- **Availability and cost for green electric power** is another **key driver**, and the main issue that needs to be considered when we look at the **long-term economic feasibility of green ammonia.**
- Key component of the commercial adoption of green ammonia will be the level of incentives provided or regulation enforcing its use. The most likely incentive could come in the form of CO2 taxation and credits.
- Significant market for green ammonia will develop in the long term by lower capital costs, efficiency gains, aggressive decarbonisation policies and lower renewable energy costs.

Centralised and decentralised models of ammonia decomposition



- In the **Centralised process**, ammonia is cracked in large scale ammonia cracking process including ammonia reformer and separation and purification.
- Pure hydrogen is then pressurized and transported in trailers to point of use.
- Typically, transported hydrogen is under a pressure between 250 and 300 bar, requiring multistage compression after the ammonia cracking unit.
- When high pressure hydrogen is delivered to point of use, it undergoes a second compression phase to reach at least 700 bar which is the conventional filling pressure for fuel cell vehicles.

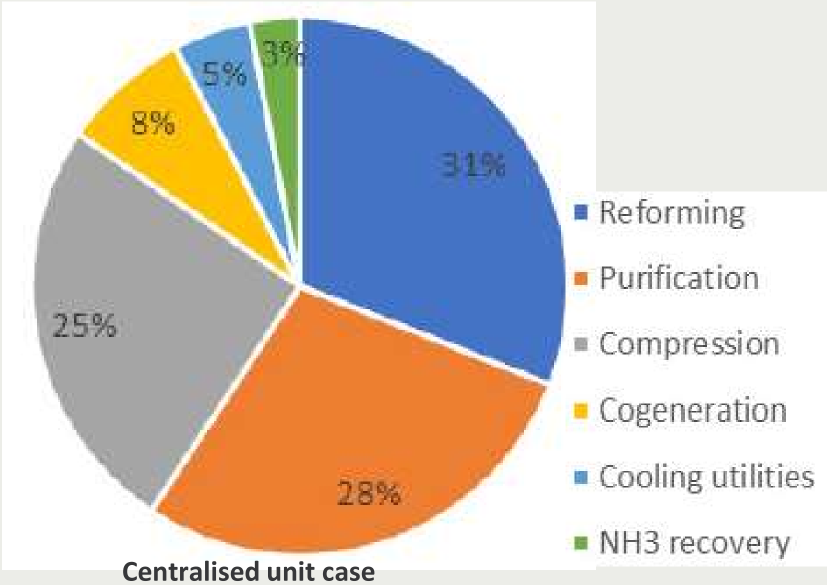


- **Decentralized pathway** does not include a decomposition process of bulk ammonia.
- Liquid ammonia is transported either using conventional tankers or pipeline grid (relatively cleaner and safer transport option compared to high pressure hydrogen)
- At point of use, ammonia is cracked onsite, using smaller reactors that could be directly integrated to filling stations.

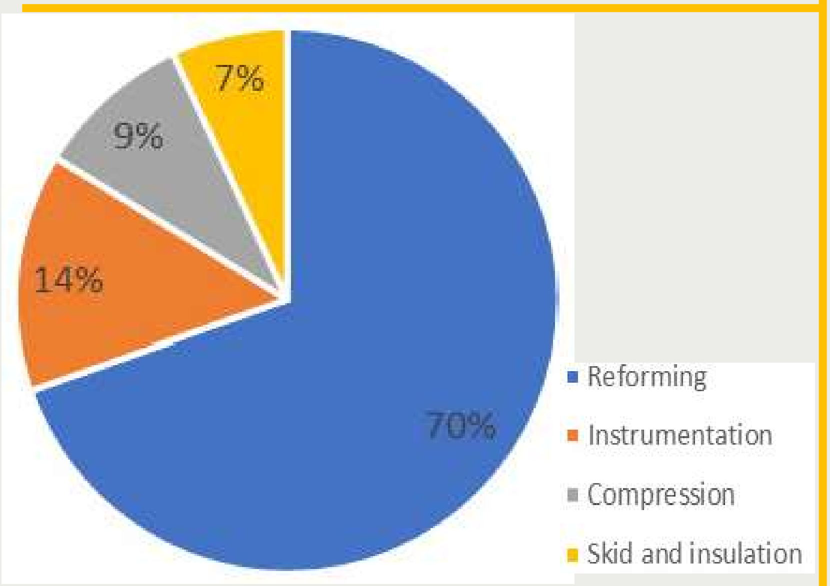
Note: #These costs are based on market rates for ammonia (Sept'19) in UK Market to deliver green fuel cell grade hydrogen **over a distance of 100km** to the point of use,

Source: UK Government, BEIS Low Carbon Hydrogen Supply Competition documents, Phase 1 report – Ecuity: Ammonia to green hydrogen project, April 2020

Equipment cost breakdown for the both* ammonia cracking units



Centralised unit case



Decentralised unit case

Total Capital Investment (TCI) is the aggregate of:

- Purchased equipment costs - all costs required to purchase equipment needed for the control system
- Direct installation costs: the costs of labour and materials for installing that equipment,
- Indirect installation costs: costs for site preparation and buildings, and certain other costs,
- Costs for land, working capital, and off-site facilities.

Centralised unit case:

- TCI is directly correlated to the key purchased equipment cost including all the components that were designed and dimensioned in the conceptual design step.

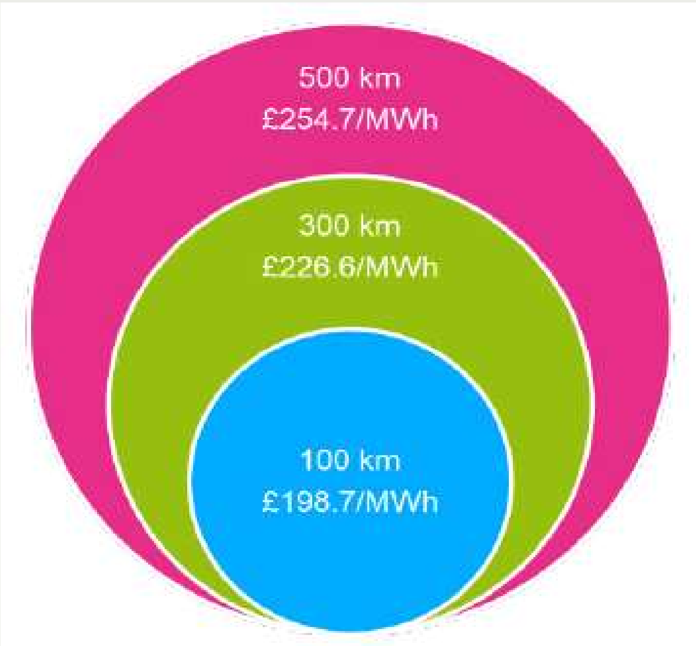
Decentralised cracker:

- Complete cost analysis is based on the conceptual design of the decentralised 200 kg/day cracker.
- First, a membrane reactor has been designed, where the volume of reactor, catalyst and membrane area have been evaluated.
- Subsequently, the costs of all the BoP components have been assessed.
- In this analysis, all the equipment costs are based on real purchases of a similar membrane reactor unit, where the target was to produce 20 Nm3/h of H2 from natural gas.
- This minimises the error margin in cost estimates and provides confidence that actual costs will be within ±5%.

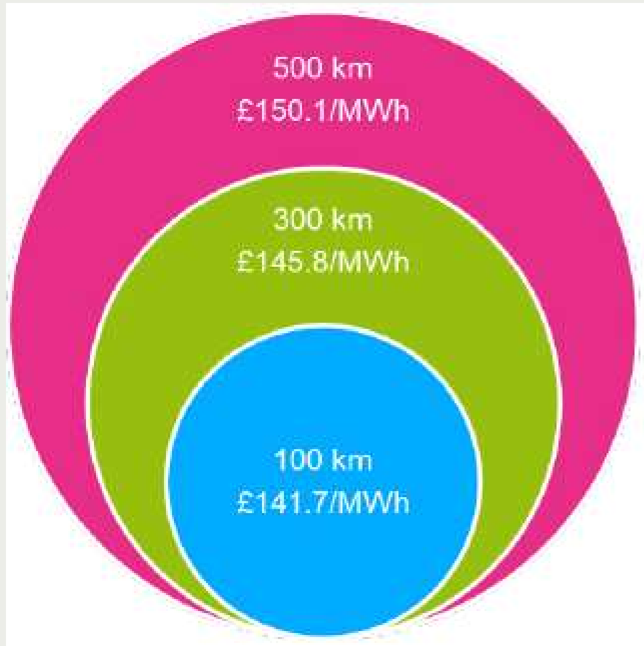
Note: *For both pathways, purchased equipment costs were estimated based on general plant layout and process requirements**.**

Source: UK Government, BEIS Low Carbon Hydrogen Supply Competition documents, Phase 1 report – Ecuity: Ammonia to green hydrogen project, April 2020

Impact of distribution radius on total cost of delivered hydrogen



Centralised unit case



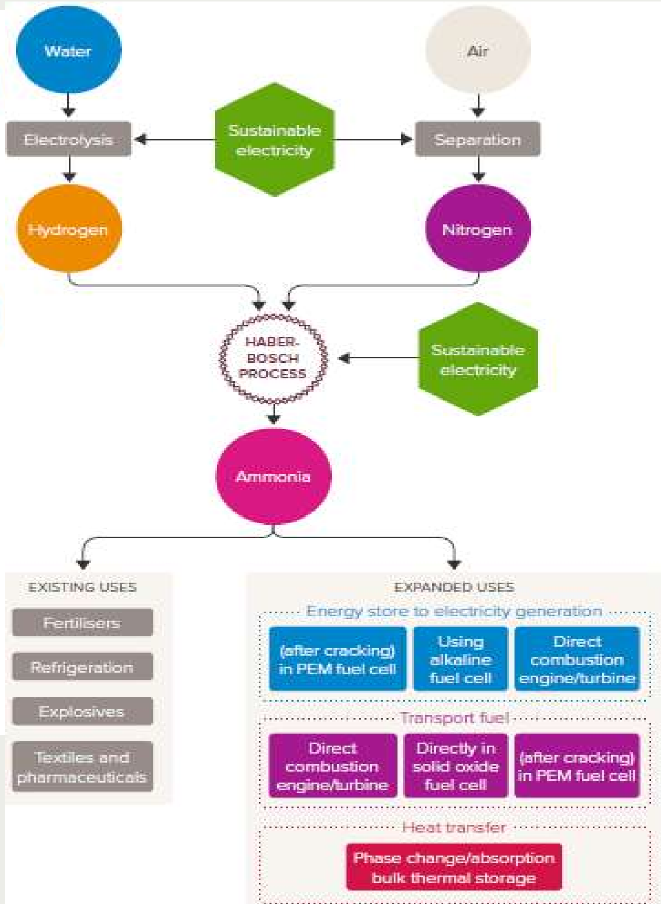
Decentralised unit case

- Cost-effectiveness of the decentralisation solution improves when the distribution radius is widened.
    - ✓ For example, at a distribution distance of 500km, hydrogen production from a decentralised facility would be almost 50% cheaper than from a centralised facility
- This demonstrates the strong potential for ammonia as a hydrogen carrier when it takes advantage of the existing infrastructure for its storage and transportation.

Source: UK Government, BEIS Low Carbon Hydrogen Supply Competition documents, Phase 1 report – Ecuity: Ammonia to green hydrogen project, April 2020

Ammonia & its market (India & Europe)

Green ammonia production and end uses



Existing usage of ammonia are:

- As fertilisers
- Textiles & pharmaceutical industries
- Industrial cold stores,
- food processing industry applications and
- large-scale air-conditioning.
- Explosives industries.

Expanded uses are:

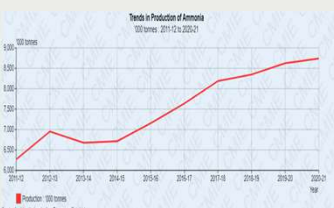
Ammonia in power generation:

- Ammonia can also be burned directly in gas turbines in a mixture with natural gas or hydrogen.
- If ammonia is imported as a hydrogen carrier, burning it directly could eliminate the requirement for ammonia cracking (needed to reconvert it into hydrogen), thus removing an energy-intensive stage of the process.
- Additionally, ammonia requires a much smaller storage volume than hydrogen.
- Ammonia is also less reactive than hydrogen, and burns at a lower temperature with reduced flame speed and a narrow flammability range.

Other expanded uses of ammonia are

- In PEM fuel cell after cracking
- Using alkaline fuel cell
- As a transport fuel
  - Direct combustion engine/turbine
  - Directly in solid oxide fuel cell
- as heat transfer (Phase change/ absorption bulk thermal storage).

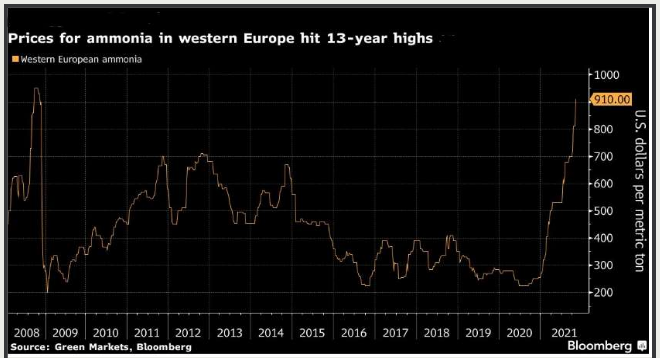
Ammonia(Grey) - Present Scenario in India

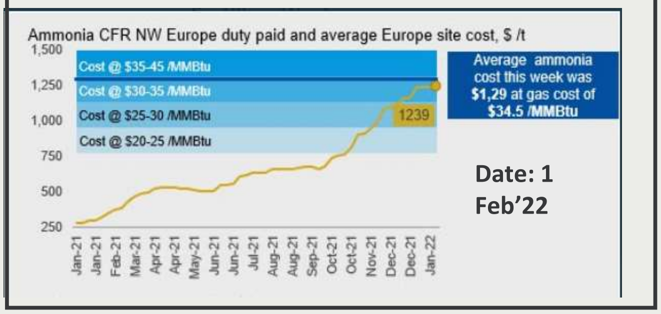


Analysis:

- **India** is one of the **largest importer of ammonia** in the world.
- India is among the largest consumers [Positive growth since 2014] of fertilizers in the world, with **domestic sales continually growing**. The major drivers of ammonia market are such as rising disposable incomes, increasing population, growing food demand, growing emphasis on production protection, and rising domestic ammonium nitrate production are expected to aid the market growth.
- **Excellent business opportunity which can be exploited as ammonia is used directly by fertilizer's, textiles & pharmaceutical industries**.
- Recently**, Ministry of Power on notified the green hydrogen and ammonia policy** under which the government is offering to set up manufacturing zones for production, connectivity to the ISTS (inter-state transmission system) on priority basis.

Ammonia(Grey) – Europe & India





DATA: CRU, Powernext
NOTE: Average cost this week calculated using average end of day TTF price

Sales Unit Value by Companies : Ammonia

India

Rs./Unit : 1995-96 to 2020-21

Rank	⇕	Unit		2011-12	2012-13	2013-14	2014-15	2020-21
1	Rashtriya Chemicals & Fertilizers Ltd.	Kgs	43	30.21	38.81	36.83	35.48	
2	Krishak Bharati Co-Op. Ltd.	Kgs	96					
3	Kribhco Fertilizers Ltd.	Kgs	12	20.39	25.35			
5	Indian Farmers Fertiliser Co-Op. Ltd.	Kgs						29.45
7	Manav Gases Pvt. Ltd.	Kgs						
10	Vadilal Chemicals Ltd.	Kgs						
12	Chambal Fertilisers & Chemicals Ltd.	Kgs	85					
	Companies Total	Cubic metres						
		Kgs	03	27.29	35.69	35.55	34.54	29.45
		Tonnes					33,724.58	

Updated on : 11 Feb 2022 06:24:29 PM

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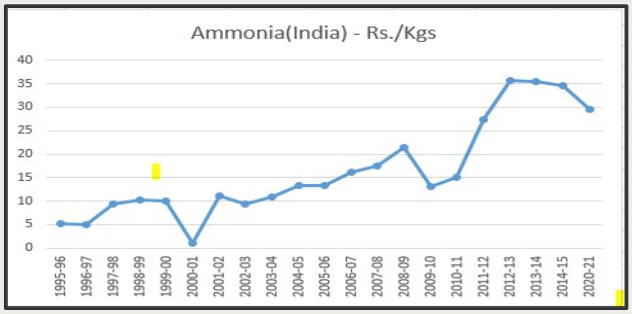
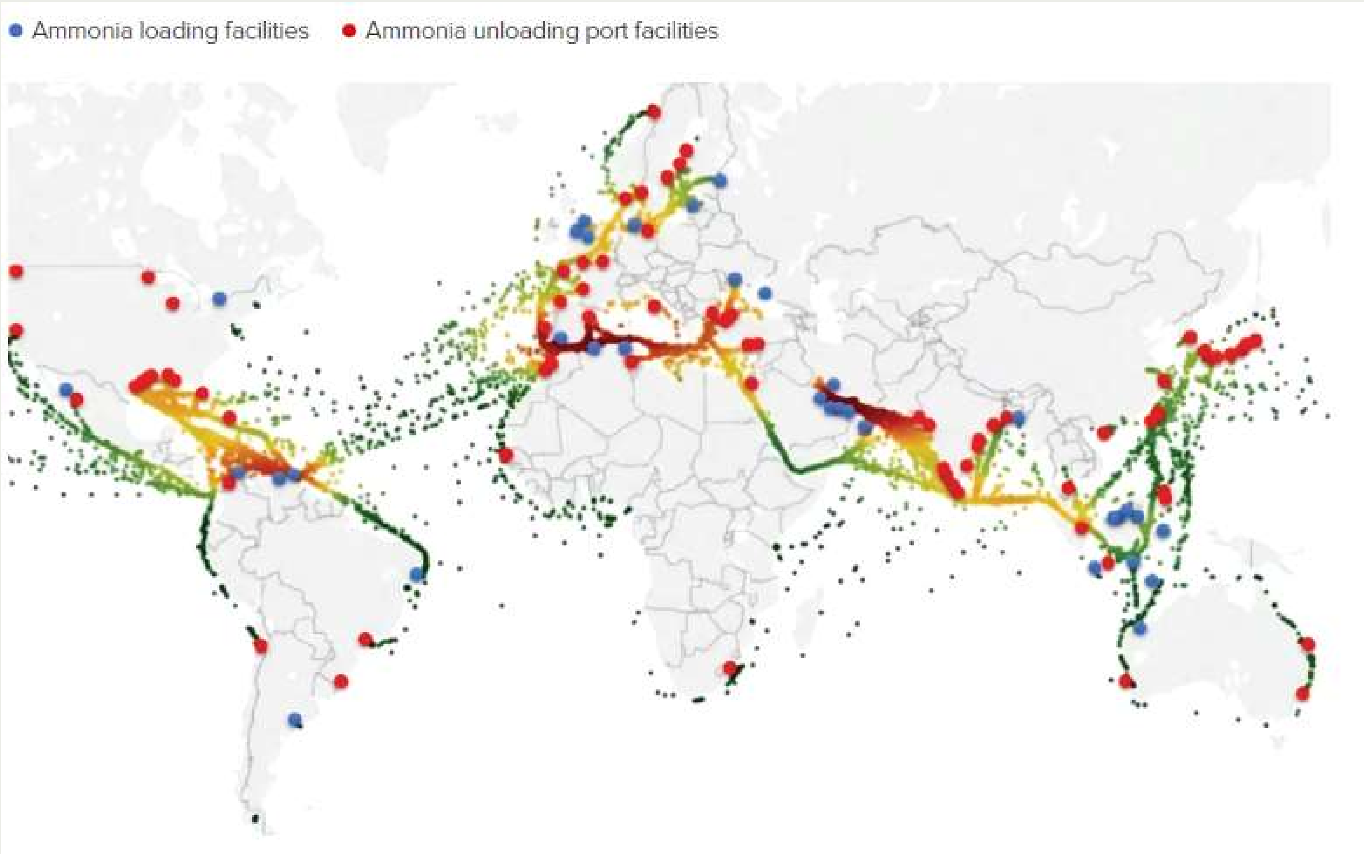


Note: This graph is prepared from the Sales unit value by companies : Ammonia (India)



Key opportunities for scaling up hydrogen to 2030

The **emergence of international distribution** is driven by cost differences for hydrogen production stemming from renewables endowment, the availability of natural gas and carbon storage sites, existing infrastructure and the ease and time requirements for its build-out, land use constraints, and the assignment of local renewables capacity for direct electrification.

Source Link – IEA 2019

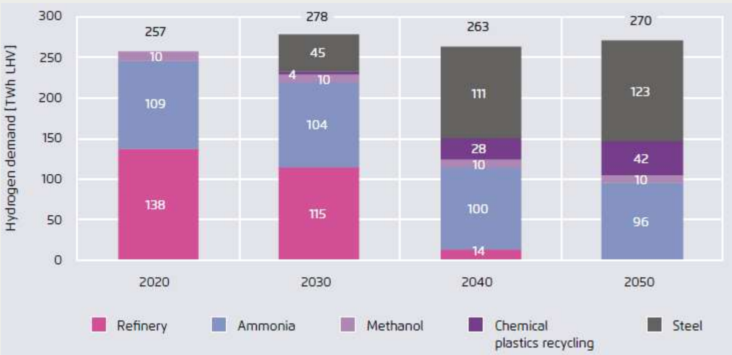
H2 value chain	End user*	Value chain steps			Cost USD/kg
		Production	Transmission	Distribution	
International	Industrial, large scale off taker	Renewable / low – carbon production 1.0 – 1.4 USD/kg	International pipeline for ~9,000km and storage at port for average of 2 week or Carrier conversion/ reconversion, shipping for ~9,000km and storage at port for average of 2 weeks 0.6-3.5 USD/kg	Trucking as LH2 for 300km & onsite storage for average of 1 day or Piping as GH2 for 300km and operating of 1,000kg GH2 HRS 0.1-2.0 USD/kg	~ 2-7

Source: Eninrac research, Hydrogen council, Mckinsey, Channel Checks

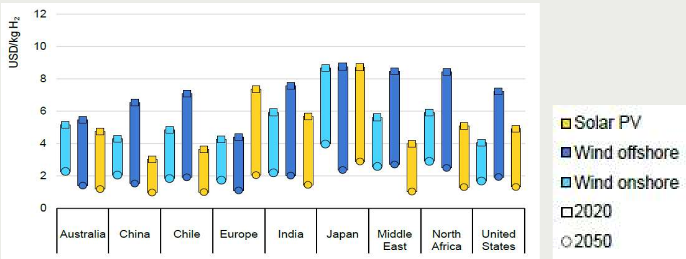
Hydrogen has varied usage in EU:

- Refining
  - i. Hydrocracking
  - ii. Hydro-treating(e.g. fuel desulfurization)
  - iii. Bio refinery
- Ammonia
  - i. Production of ammonia (for urea & other fertilizers)
- Methanol & derivatives
- Other chemicals (e.g. Polymers, Polyurethanes, fatty acids)
- Processing
  - i. Heat Treating of steel
  - ii. Welding of metals
  - iii. Forming & blanketing gas
  - iv. Glass Production
- Liquefied hydrogen
  - i. Rocket fuel
  - ii. Automotive fuel
  - iii. Semi-conductor industry

Forecasted demand for industrial hydrogen in Europe from 2020 to 2050, by sector(in terawatt hours)



Levelised cost of hydrogen production from renewables by technology and region in the Net zero Emissions Scenario, 2020 and 2050



Notes: Higher values of the ranges correspond to 2020, lower values to 2050.
Sources: Based on data from the Hydrogen Council; IRENA (2020).

Hydrogen industry's economic outlook in the EU 2030

Forecast key economic indicators of the hydrogen industry in the European Union in 2030*

	Market value (in billion euros)	Employment (in 1,000)
Hydrogen market (imports)	20	150
Intra-EU trading	65	450
Hydrogen industry (exports)	65	450

Source – Agora, No-regret hydrogen: Charting early steps for H² infrastructure in Europe, page 10

*Underlying assumption is "ambitious scenario" whereby hydrogen will be fully utilized to stave off a global temperature increase of more than two degrees Celsius, with all EU member states adhering to Paris Climate Agreement.
Details: EU;2019 **Source link:** FCHE - Hydrogen Roadmap Europe, page 58

Forecast green hydrogen electrolysis capacity and investment volume in selected European countries in 2030	Electrolysis capacity (in gigawatts)	Investments (in billion euros)
France*	6.5	7.2
Germany*	5	9
Italy*	5	10
Spain*	4	8.9
Netherlands**	3.5	
Portugal***	2.3	8
Austria****	1.5	

*Spent public funds for France and Germany; mobilized investments for Italy and Spain.
** Electrolysis target between three and four gigawatts.
*** Electrolysis target between two and two point five gigawatts. Investment target between seven and nine billion euros.
**** Electrolysis target between one and two gigawatts.
Source: Statista, hydrogeneurope.eu, Dec 2020

Hydrogen demand and electrolysis capacity outlook in the EU 2050

Forecast hydrogen demand and electrolysis capacity in the European Union in 2030 and 2050

	Demand (in terawatt hours)	Electrolysis capacity (in gigawatts)
2030 (scenario A)*	30	7
2030 (scenario B)**	140	35
2050 (scenario A)*	800	341
2050 (scenario B)**	2250	511

* Scenario A assumes a largely electrified world and electrification of all sectors, with a relatively small share of material energy carriers used.
** Scenario B, meanwhile, expects material energy carriers to continue playing a role in covering energy demand, although fossil fuel shares will be eclipsed by renewables.
Details: EU; Fraunhofer ISE; 2019, **Source**: Statista

Production costs of green hydrogen worldwide by select country in 2020, with a forecast until 2050 (in euros per kilogram)

Countries	2020 min	2020 max	2030 min	2030 max	2050 min	2050 max
Argentina	4.25	4.50	2.25	2.50	1.25	1.50
Australia	4.50	4.75	2.50	2.75	1	1.25
Brazil	4.50	4.75	2.25	2.50	1	1.25
Canada	3.75	4	2.50	2.75	1.25	1.50
Chile	3.50	3.75	2	2.25	1	1.25
China	4	4.25	2	2.25	1	1.25
France	4.25	4.50	3	3.25	1.75	2
Germany	4.75	5	3	3.25	2	2.25
India	4.25	4.50	2.50	2.75	1	1.25
Japan	6.25	6.50	3.75	4	2.50	2.75
Morocco	4.25	4.50	2.50	2.75	1	1.25
Poland	5	5.25	3.25	3.50	2.25	2.50
Russia	3.75	4	2.25	2.50	1.25	1.50
Saudi Arabia	4.25	4.50	2.25	2.50	1	1.25
South Africa	4.25	4.50	2.50	2.75	1	1.25
South Korea	6.25	6.50	3.75	4	2.50	2.75
Spain	4.75	5	2.50	2.75	1	1.25
Sweden	7.25	7.50	4.50	4.75	2.75	3
United Kingdom	3.75	4	2.50	2.75	1.75	2
United States	4.25	4.50	2.50	2.75	1	1.25

Chile currently has the lowest production costs of green hydrogen worldwide. As of 2020, the country's current renewables infrastructure allowed for green hydrogen generation ranging between 3.5 and 3.75 euros per kilogram. The market for green hydrogen is still in its infant stage.
Source: Statista

S#	Technology	Description	Adv/Disadv
Compression			
(i)	Low pressure tanks	(i) No additional compression needed from hydrogen production. (ii) Only used for stationary storage where lower quantities of hydrogen are needed relative to available space.	+ Established technology **- Poor volumetric energy density**
(ii)	Pressurised tanks	(i) A mechanical device increases the pressure of the hydrogen in its cylinder. (ii) Hydrogen can be compressed and stored in steel cylinders at pressures of up to 200 bar. While composite tanks can store hydrogen at up to 800 bar49, pressures typically range from 350 to 700 bar. (iii)Compression is used for both stationary storage and transport of hydrogen.	+ Established technology **- Low volumetric energy density** **- energy intensive process**
(iii)	Underground Storage	(i) Hydrogen gas is injected and compressed in underground salt caverns which are excavated and shaped by injecting water into existing rock salt formations. (ii) Withdrawal and compressor units extract the gas when required.	+ High volume at lower pressure and cost **+ Allows seasonal storage** **- Geographically specific**
(iv)	Line packing	A technique used in the natural gas industry, whereby altering the pipeline pressure, gas can be stored in pipelines for days and then used during peak demand periods.	+ Existing infrastructure **+ Straightforward hydrogen storage technique at scale**
Liquefaction			
(i)	Cryogenic tanks	Through a multi-stage process of compression and cooling, hydrogen is liquefied and stored at -253˚C in cryogenic tanks. Liquefaction is used for both stationary storage and transport of hydrogen.	+ Higher volumetric storage capacity + Fewer evaporation losses **- Requires advanced and more expensive storage material**
(ii)	Cryo-compressed	Hydrogen is stored at cryogenic temperatures combined with pressures approaching 300 bar.	+ Higher volumetric storage capacity + Fewer evaporation losses **- Requires advanced and more expensive storage material**
Material based			
(i)	Ammonia (NH3)	Hydrogen is converted to ammonia via the Haber Bosch process. This can be added to water and transported at room temperature and pressure. The resulting ammonia may need to be converted back to hydrogen at the point of use.	**+ Infrastructure is established** **+ High hydrogen density** (17.5% by weight) - Plants need to run continuously - Energy penalty for conversion back to hydrogen

Hydrogen – Chemical Storage Technologies

CHEMICAL STORAGE

Hydrogen Storage

Types
- **Physical storage:** Compressed gas, cold/cryo and liquid H_2
- **Storage material:** Adsorbent (Graphene), liquid organic hydrogen carriers (Cycloalkanes), complex hydrides (LiBH4),etc.

ADVANTAGES

Physical storage
- **Compressed gas:** Mature technology
- **Liquid H_2:** High storage density (70.8 kg/m³)
- **Cryo-compressed:** High volumetric capacity

Storage material
- **Metal hydrides:** Low operating energy
- **Carbon materials:** High hydrogen storage capacity
- **Chemical hydride (AlH_3):** Good volumetric capacity

DISADVANTAGES

Physical storage
- **Compressed gas:** Low volumetric density (<40 kg H_2 m³), high compression energy, etc.
- **Liquid H_2:** H_2 loss, safety issue, high liquefaction energy
- **Cryo-compressed:** High compression/ liquefaction energy

Material based
- **Metal hydrides:** Low gravimetric/volumetric capacity, high operating temperature
- **Carbon materials:** Low volumetric density, loss of useable H_2, low operating temperature
- **Chemical hydride (AlH_3):** Thermal management required

Synthetic Natural Gas (SNG)

ADVANTAGES
- Easily transportable via pipelines
- 70% less CO_2 as compared to other fossil fuels
- Does not produce ashes after energy release
- Inexpensive compared to coal
- Can be used as an automotive fuel
- Low levels of criteria pollutants, (e.g. SOx, NOx) or soot when burned

DISADVANTAGES
- Volume is almost four times of petrol, which makes it expensive to store
- Difficulty for leak detection
- Expensive gas infrastructure
- Stored and distributed under high pressure

Methanol

ADVANTAGES
- Higher volumetric energy density over hydrogen
- Easy to transport and it can be reformed locally to produce hydrogen

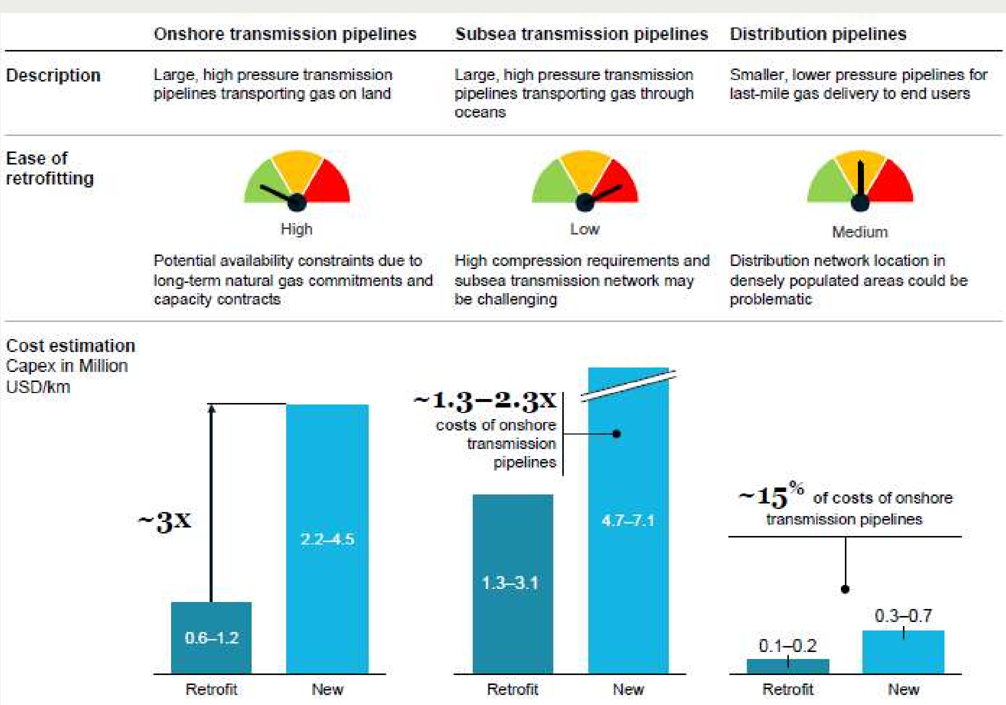
DISADVANTAGES
- Corrosive
- Need of catalysis
- Need of up-scaling and further development of methanol reactor unit

Green Ammonia

ADVANTAGES
- Abundant feedstocks; same properties as Liquefied Natural Gas (LPG)
- Liquid ammonia density is 70% more than liquid hydrogen and three times more than compressed hydrogen
- Green ammonia produced from water electrolysis has potential to reduce ~1.6% of current global emissions
- Easily liquefiable

DISADVANTAGES
- Currently, energy required for ammonia production mainly comes from fossil fuels
- Lower reactivity compared to hydrocarbons
- Requires corrosive resistant components

Different hydrogen pipelines

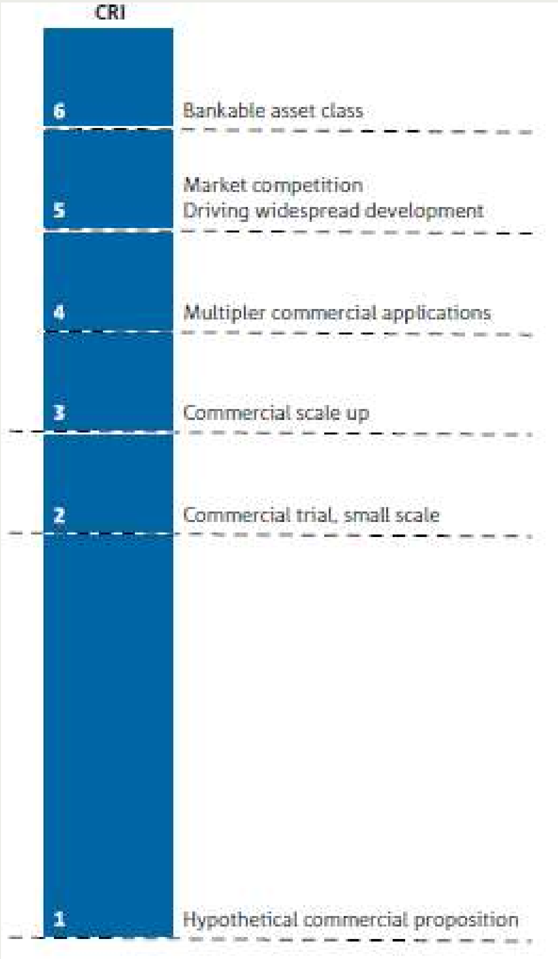


Note:
- The costs of retrofitting versus building new pipelines depend on a variety of factors including diameter and pressure, the quality of the materials used, the pipeline's overall condition, the existence of cracks, the social costs of construction, and other considerations. Many of these factors are location-specific and thus give some regions and countries an advantage for retrofitting the natural gas grid.
- The costs of retrofitting can change based on pipeline upgrades and the presence of connected equipment such as metering stations, valves, and compressor stations.

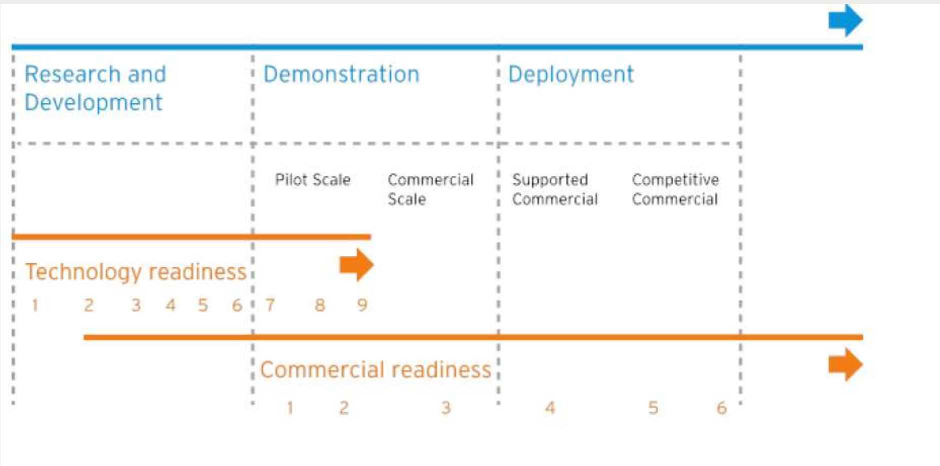
Repurposed pipelines are **significantly cheaper** than new hydrogen pipelines

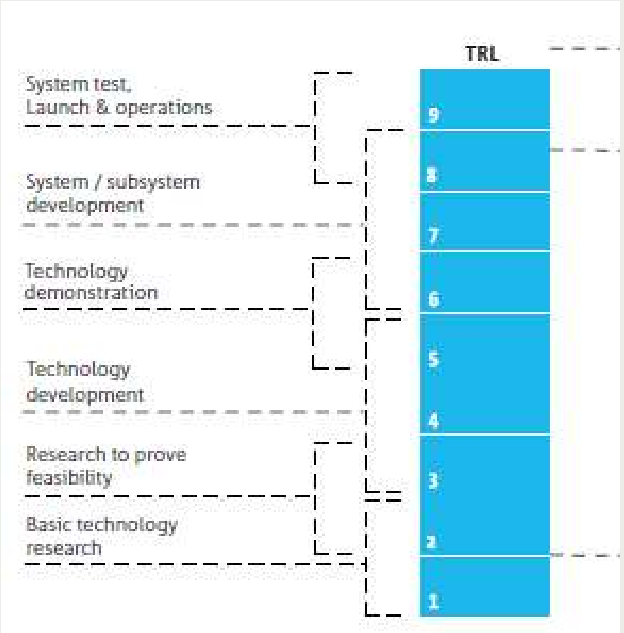
Green Hydrogen – Technological and commercial readiness index(Status'21)

- The hydrogen value chain now consists of a series of relatively mature technologies with a high 'Technological Readiness Level' (TRL) but low Commercial Readiness Index (CRI) (according to the scale depicted in Figure).
- This is evidenced by the number of pilot projects demonstrating use of hydrogen across multiple applications globally. While there is considerable scope for further R&D, this level of maturity has meant that the narrative has shifted from one of technology development to market activation. **Green hydrogen is now at commercial scale up**.
- The figures also demonstrate that the CRI begins once the technology is at the stage where there is research to prove that it is feasible in the field (TRL 2).
- The CRI extends to when the technology or application is being commercially deployed and has become a bankable asset class (eg. Status Summary Level 6).



Source: IEA





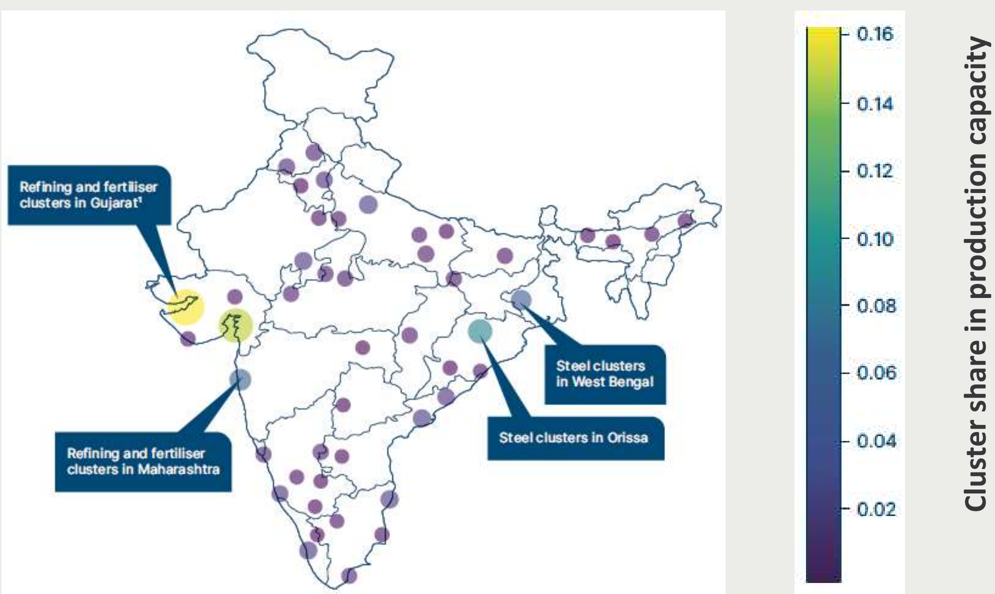
Technological and commercial readiness index

Green Hydrogen – Integration readiness of various use cases

- Hydrogen is currently used primarily in industrial applications, including oil refining, steel production, ammonia and methanol production, and feedstock for other smaller-scale chemical processes.
- Green hydrogen is best positioned to reduce CO2 emissions in typically “hard-to-decarbonize” sectors such as cement production, centralized energy systems, steel production, transportation and mobility (e.g., forklifts, maritime vessels, trucks and buses), and building heat and power systems.
- Natural gas utilities are likely to be early adopters of green hydrogen as methanation (i.e., combining hydrogen with CO2 to produce methane) becomes commercially viable and pipeline infrastructure is upgraded to support hydrogen blends.
- Material handling equipment (e.g., forklifts) and industrial use cases (e.g., oil refining, ammonia and methanol feedstock) are currently among the more widely adopted use cases for green hydrogen
- Near-term (as the decade progresses), “mass market acceptability” (i.e., sales >1% of the market) could occur for applications such as heavy-duty trucking, city buses, de-carbonization of feedstock and hydrogen storage, among others
- Longer-term (i.e., beyond 2030), commercially viable green hydrogen applications are expected to expand to other mobility segments (e.g., drop-in synthetic fuels), steel production, and blending with natural gas and heating applications across dedicated infrastructure

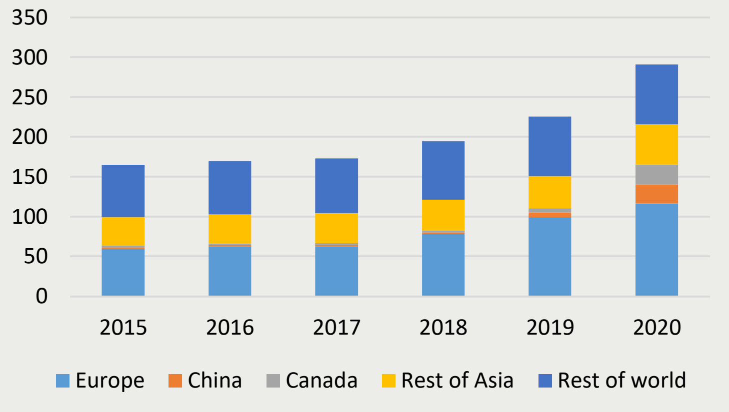
Hydrogen Clusters(India)

Spatial analysis in India identified 46 favourable clean hydrogen industrial cluster locations



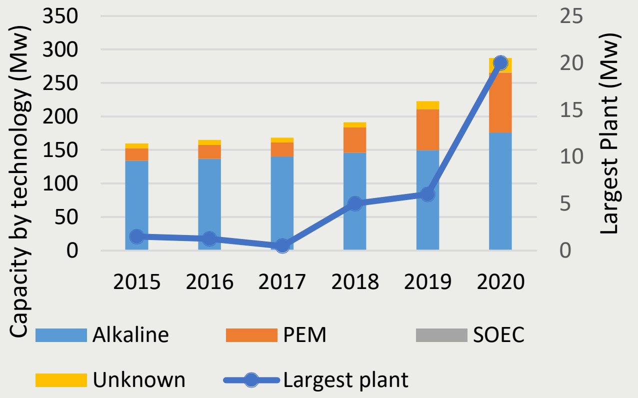
Source: TERI/ETC India analysis published in TERI 2020, The Potential role of hydrogen in India

Global installed electrolysis capacity by region , 2015-2020



Sources: IEA (2021), Global Hydrogen Review 2021

Global installed electrolysis capacity by Technology, 2015-2020

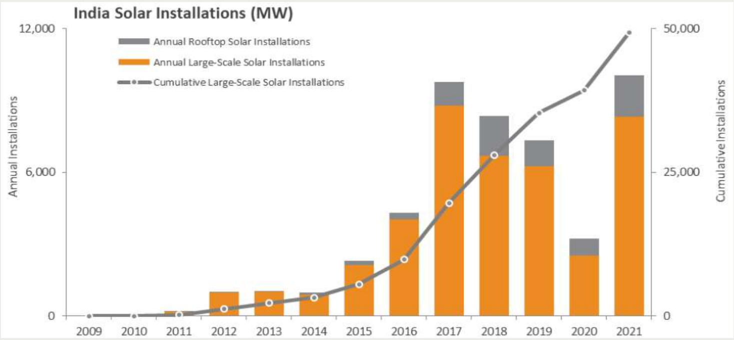


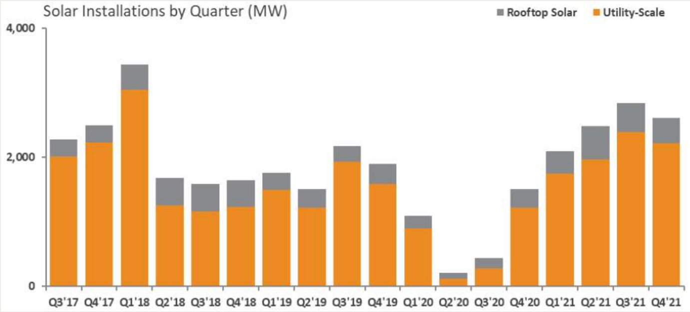
Sources: IEA (2021), Global Hydrogen Review 2021

Notes: PEM = polymer electrolyte membrane. SOEC = solid oxide electrolyser cell. Capacities cover only dedicated production of hydrogen

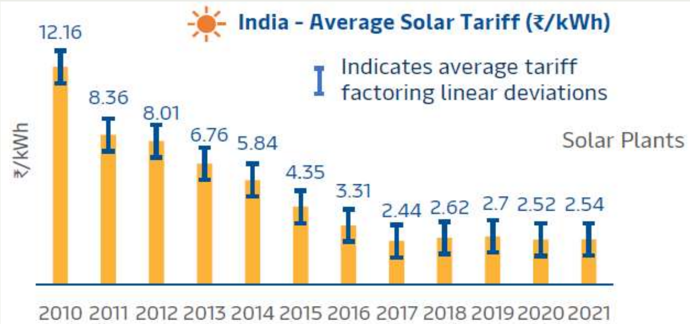
India Solar Installations - At a Glance

- In 2021, India added over 10 GW of solar, an increase of 210% YoY compared to 3.2 GW in 2020.
- Solar accounted for ~62% of the new power capacity additions in CY 2021
- India's cumulative solar installations reached 49 GW at the end of Q4 2021
- Large-scale solar project pipeline for India stood at 53 GW
- India's solar power generation totaled 17.1 billion units (BU) in Q4 2021
- Solar represented ~12.4% of the total installed power capacity in India as of Q4 2021





Source: MERCOM India Research (Dec,2021)



Source: Eninrac research & analysis, CEA, MNRE GoI, SERCs Tariiff Orders & Channel Checks

Solar PV project value chain

Outline below of a supply chain for a utility-scale solar PV plant illustrates the specific goods and services that typically comprise solar PV supply chains.	
Project planning - Activities at the project planning phase comprise site selection, technical and financial feasibility studies, engineering design, and project development. - Requires equipment to measure solar resources at the site, such as pyranometers and pyrheliometers, along with solar energy simulators and programmes to predict the availability of solar resources. It also requires computers and software to run simulations and produce feasibility analyses.	**Transport** The components of a solar PV plant can be transported by truck, plane, train or boat, with no special handling needed apart from proper packaging to avoid damage. **Installation and grid connection** - mainly comprise site preparation and civil works. - The materials and equipment needed during the installation phase principally include glass, steel, aluminium, concrete, silicon, copper and plastic. - Equipment includes loaders, cranes, high-tonnage trucks and excavators, as well as supervisory control and data acquisition ("SCADA") equipment and electrical and electronic instrumentation and control
Procurement and manufacturing - The materials needed to manufacture commonly used PV panels are glass for the panel surface, as well as polymers, aluminium, silicon, copper, silver and other metals. - The materials required to produce inverters depend on their size, model and casing, and may include aluminium, polymers and steel (in the screws and clamps). - The materials needed to build the structures depend on the type of installation and may include aluminium, steel, concrete, plastic, polymers and corrugated board. - Manufacturing the main components of a solar system requires specialized equipment and other machinery. In addition, it requires equipment which is commonly used in other industries such as machines for cutting, welding, washing, bending, melting and joining. Electronic and information technology tools are also extensively used in manufacturing for monitoring and controlling machinery.	**Operation and maintenance activities** - These take place during the entire expected lifetime of a PV plant (about 25 to 30 years). - Modern PV plants are automated and controlled by SCADA. Their operation is normally monitored remotely. - Key activities during this phase are preventive and corrective maintenance, such as cleaning the panels. **Decommissioning a PV plant** This involves planning the activity, dismantling the project, recycling or disposing of the equipment, and clearing the site.

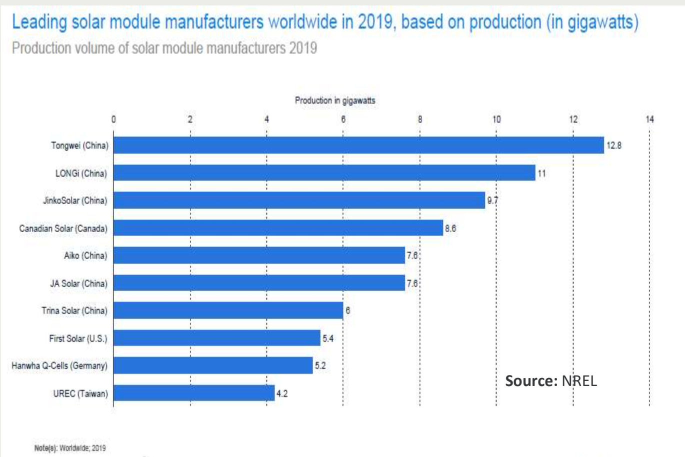


Fig 1

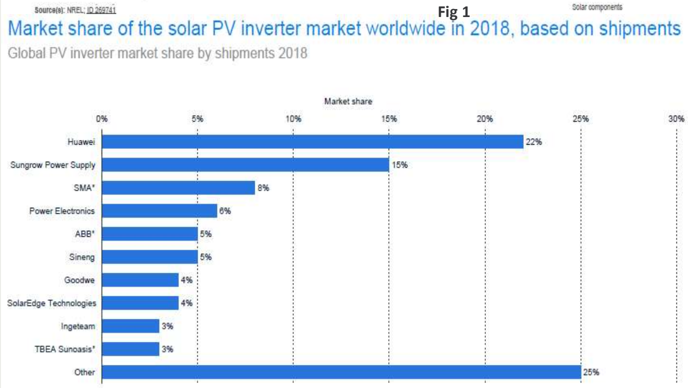


Fig 2

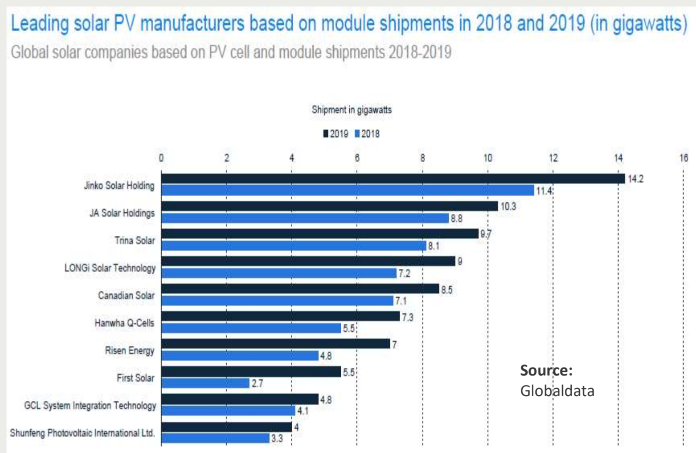


Fig 3

Fig 1: China's Tongwei Solar produced modules with a capacity of around 12.8 gigawatts in 2019.Of the ten most prominent manufacturers of solar cells, six are based in China.

Fig 2: This graph displays the market share of the global PV inverter market based on the number of shipments in 2018. In this year, Huawei accounted for 22% of the PV inverter market shipments worldwide.

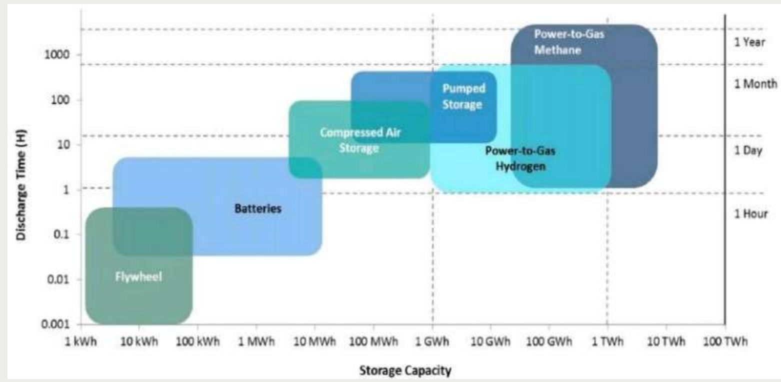
Fig 3: The statistic shows the leading global solar manufacturers for photovoltaic (PV) cell and module shipments in 2018 and 2019. Chinese solar cell and module manufacturer, Jinko Solar Holding, was ranked in first place, with shipments amounting to 14.2 gigawatts in 2019.

Source: Greentech media

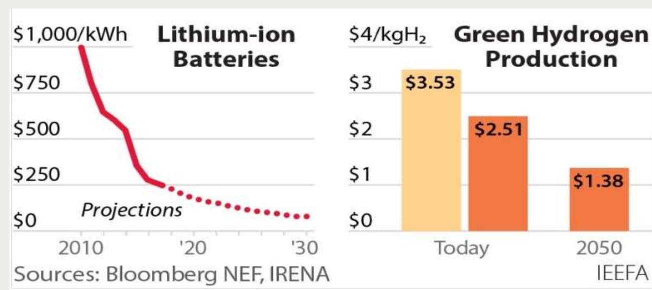
Energy storage Technologies

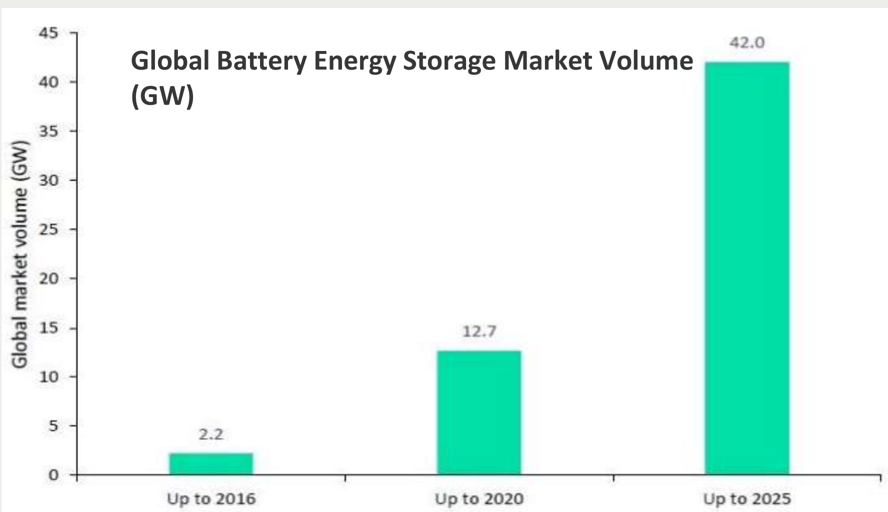
Analysis:

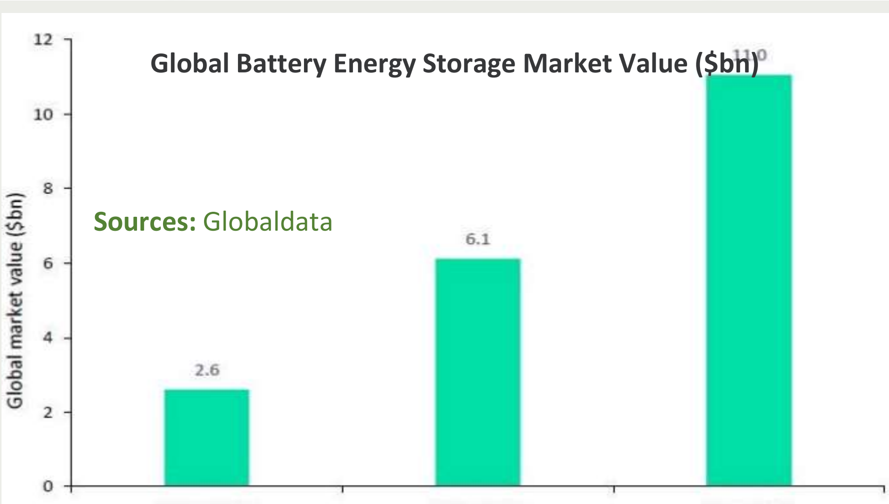
- Energy Storage technologies differ in the terms of the system configurations and design parameters.
- The technologies are differentiated in terms of
  - Technology maturity
  - Capacity (Energy & Power density)
  - Storage duration
  - Standby time
  - Response time
  - Number of lifecycles
  - Storage losses
  - Conversion efficiency
  - Thermal rating
  - Safety aspects
  - Being Stationary or mobile
  - Impact to environment



Energy storage - Battery market size & growth







Analysis:

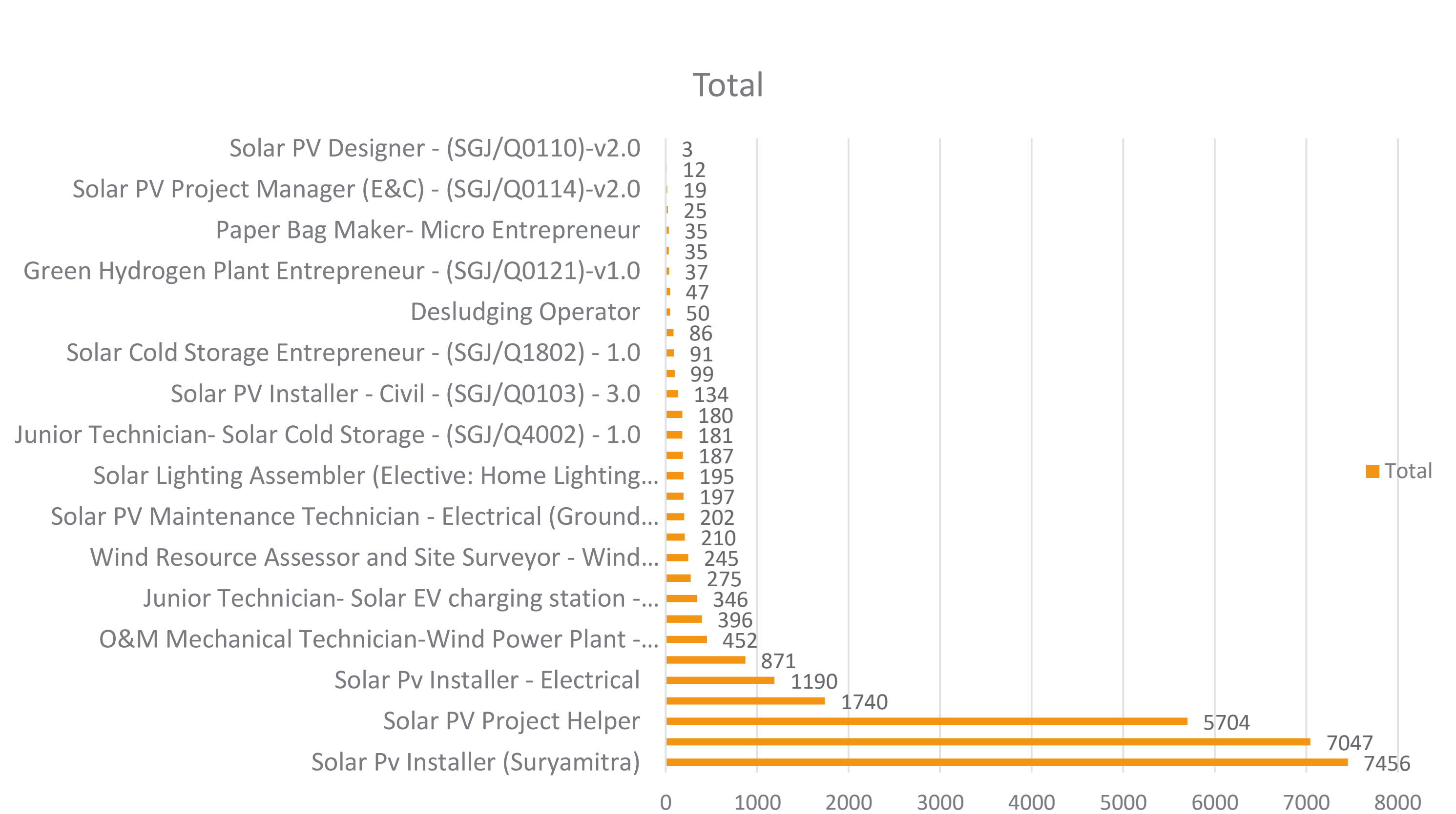
- Globally, the battery energy storage deployment stood at around **12.7 GW in 2021**.
- The market has grown by more than five times in the last 5 years.
- The deployment is expected to **reach around 42 GW by 2025**, growing at CAGR of 27%.
- The **market for battery energy storage is estimated to grow to $11bn in 2025**.
- Several **factors could contribute to such growth**; primarily, the fall in the battery technology prices and the **increasing need for grid stability & resilience for the integration of renewable power** in the power market.
- Globally the cost of battery storage has reduced dramatically – from US$1,100/kWh in 2011 for a standalone lithium-ion battery set-up, the price is projected to drop to US$58/kWh by 2030.

SCGJ Statistics through FY 23-24

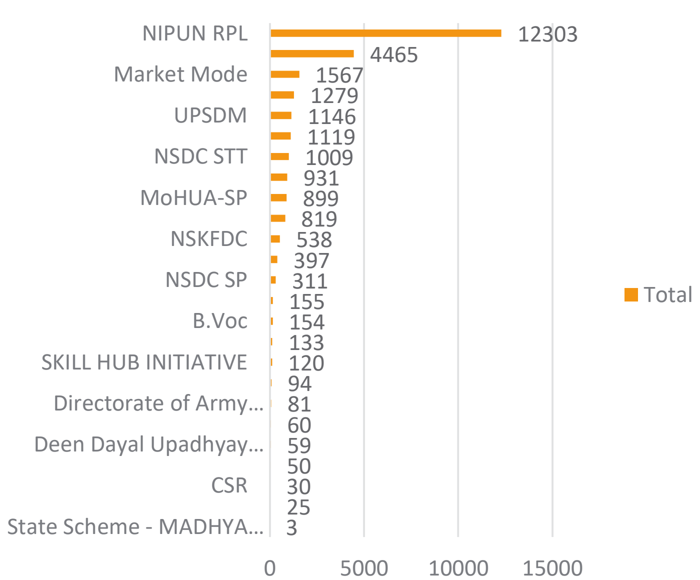
Trainings

Total Training I 27,747
Cumulative Training | 5,36,397

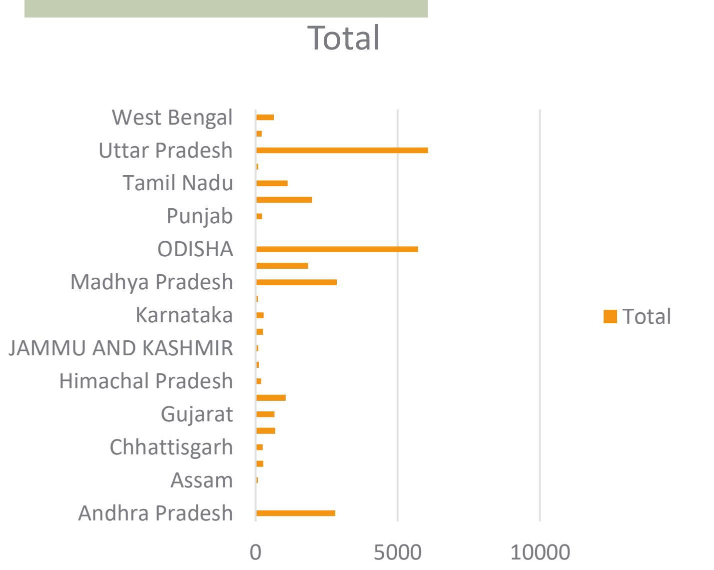
Job Role Wise



Scheme Wise

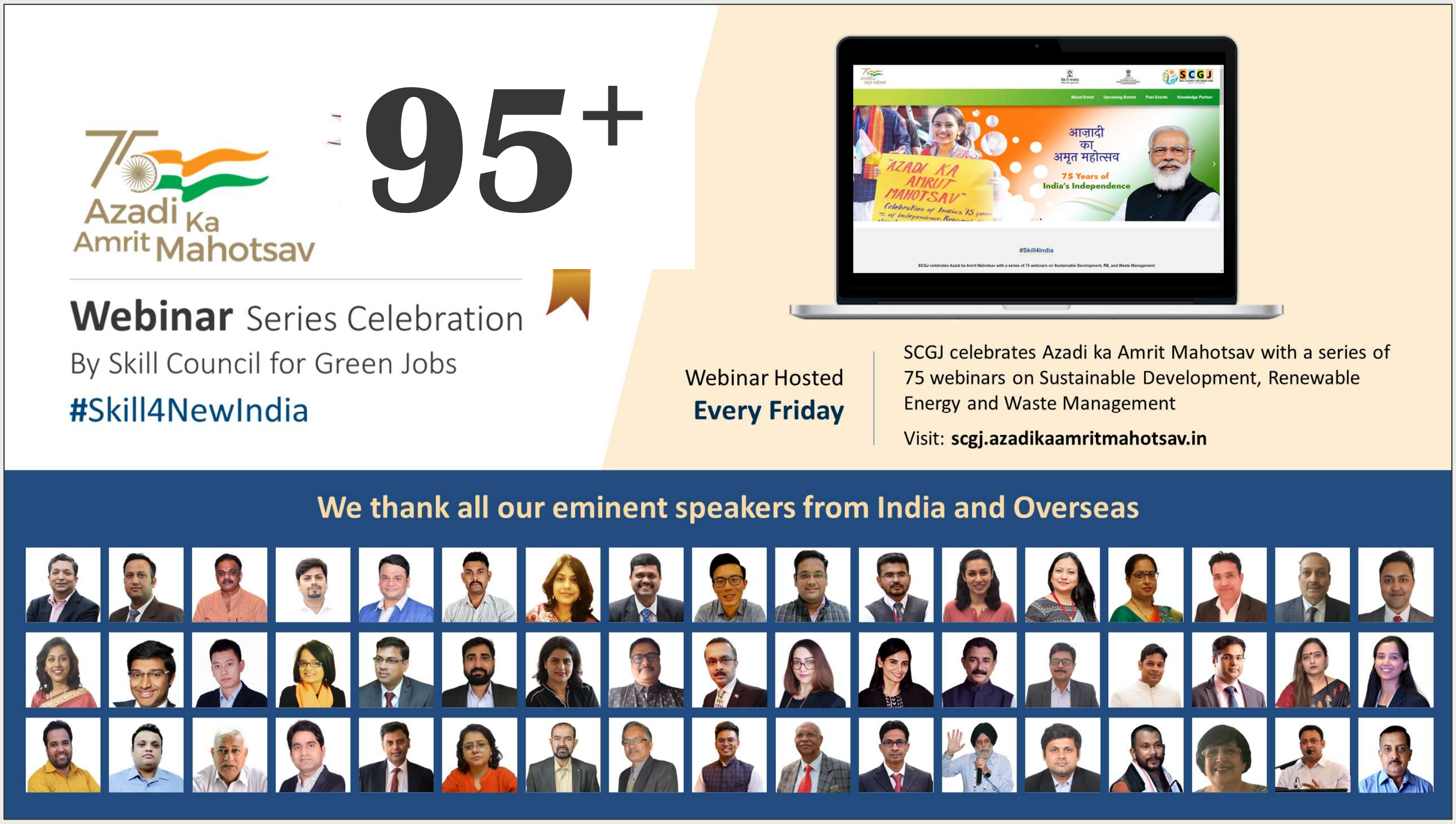


State Wise



Azadi Ka Amrit Mahotsav

Proceedings of Webinar Series



Celebration of 75 years of India's Independence

Government of India is commemorating 75 years of progressive India and the glorious history of it's people, culture and achievements by celebrating 'Azadi Ka Amrit Mahotsav'. The 75th anniversary of India's independence is a testament to its march from a young nation to an economic superpower today. Much of this journey has been possible due to the rich heritage of skills and craftsmanship that has strengthened the country. It is indeed a step towards aligning all its efforts with the larger vision of building a New India. As a part of the 'Azadi ka Amrit Mahotsav' 2021-22, Skill Council for Green Jobs (SCGJ) is organizing a series of Webinar on Sustainable Development, Renewable Energy and Waste Management by inviting eminent and learned Speakers so as to deepen the understanding of recent developments in these sectors.

The first in the series was launched on 24th September 2021 by Mr. Sameer Gupta – Chairman (SCGJ) and Dr. Praveen Saxena – CEO (SCGJ). SCGJ is continuing to bring eminent Speakers in diverse field/sectors so to enhance knowledge and learning and bring forth various development and innovation in Renewable Energy(RE) and waste management as a part of the 'Azadi ka Amrit Mahotsav' 2021-22.

By September 2023, a total of **95 webinars have been organized** on different topics.

SCGJ is presenting the proceeding of the events in this and upcoming newsletters.

Panel Discussion on 'The rise of Green Hydrogen economy

Panel Discussion on 'The rise of Green Hydrogen economy, were conducted on 11th November 2022 as one of the initiative to promote green hydrogen in the country. The panel discussion was focused on the existing and future market along with different technologies for electrolysis and storage facilities.

Speaker Profile

Dr. Jayakrishnan, Architect, Bosch Global Software Technologies:

Dr. Jayakrishnan has over all work experience of over 12 years in the field of research and development and project management. He is currently working as an Architect with BGSW since 2018. He has experience of working with different Indian and Japanese automobile OEMs and has been part of BS6 stage emission complaint vehicle development for different OEMs. Prior to joining Bosch, he was working as a Project Scientist at IIT Delhi and has handled several research projects during his tenure. His research topic included development of low emission vehicle for transportation with focus on Hydrogen, biofuel etc. He was awarded the degree of Doctor of Philosophy (Ph.D) for work in the field of application of hydrogen fuel for automotive application from IIT Delhi in 2018. He also holds M.Tech degree in Energy & Environment management from IIT Delhi and B.Tech in Automobile Engineering from University of Kerala. He has several publications in reputed international journals.

Mr. Bikesh Ogra, CEO and Managing Director, Jakson Green Pvt. Ltd.. td.

Mr Bikesh Ogra is CEO & MD for Jakson Green Pvt. Ltd. With over 26 years of experience in the energy and construction space, his entrepreneurial acumen helped facilitate and build from inception, a Global Standard, Engineering and construction business, in India and international markets. As Global C.E.O. and Member of the board for STERLING & WILSON Solar Private Limited, he provided visionary leadership for turnkey EPC services for renewable power producers across 5 continents, helping them build 10,000MW of solar power plants while also creating an enviable operations and maintenance fleet of over 8200MW globally. Under his leadership, the solar business of Sterling & Wilson expanded from India to over 26 nations worldwide within 6 years, enroute making them the world's largest Solar EPC in 2019. His vision & entrepreneurship abilities were recognized on many global platforms and he was awarded Green Entrepreneur of the year by Entrepreneur India, 2018 and Solar Entrepreneur of the year by the Middle East Solar Industry Association, U.A.E., 2017. Some of his core competencies besides of scaling businesses, has been to mentor and build a sense of ownership in teams who in turn get self-driven, help provide strategic foresights, invest time and effort in new and upcoming technologies.

Mr. Sunil Jain, Operating Partner, Energy Transitions, Essar Capital

Mr Sunil Jain has over four decades of experience across industries including renewable energy, automotive, infrastructure, manufacturing and cleantech. Currently he is an Operating Partner for Energy Transitions at Essar Capital. Prior to Essar, he was the CEO & ED at Hero Future Energies, which is one of India's leading Renewable energy companies. Under his leadership, the company grew into one of the largest IPPs in India. Prior to Hero, he played an instrumental role in establishing Green Infra Limited and making it achieve a prominent position in the industry amongst renewable IPPs in India. He is a passionate advocate for sustainability and has been actively promoting stable and meaningful policies to enhance the cause of green energy. He has been involved in introducing new concepts of power selling in the Indian renewable sector especially wind. He has been associated with the Indian Renewable Energy Industry for the last 14+ years and has been an advocate for the sector at various domestic and international platform.

Dr. Anand M Shivapuji, Centre for Sustainable Technologies, IISc Bangalore

Dr. Anand M Shivapuji is a Senior Research Scientist at the Centre for Sustainable Technologies; Indian Institute of Science; Bangalore. His research areas include Production of Green Hydrogen and Green Chemicals, Air and Oxy-steam gasification of coal and biomass, Solid Oxide Fuel Cells and Proton Exchange Membrane Fuel Cells, Internal Combustion Engines – Adaptation for syngas and Pressure/Vacuum swing adsorption systems, etc. With over 17 years in R&D, he has handled various research projects with over 100 Crores of funding from various agencies and he has also undertaken multiple consultancy assignments with industry including TATA Motors; Cummins; AVL Graz; MANN-HUMMEL; etc.

Mr. Santosh Gurunath, Co-Founder, Umagine Energy

Mr. Santosh Gurunath is a Chemical Engineer with a Master degree from the Netherlands with over 10 years of experience across Oil & Gas with Shell and management consultancy with McKinsey and BCG. He is leading Umagine since the past 3 years, focusing on accelerating the low carbon hydrogen economy as a technology and consulting company. Originally started in the Netherlands, Umagine is now based in Ahmedabad and works across strategy, policy, technology, engineering and development of low carbon hydrogen projects.

Mr. Anurag Jain, Director, Uneecops Solar

As a Director of Uneecops Solar, Mr. Jain oversees the organization-wide innovation and drives its strategic planning & growth initiatives. Uneecops solar is one of the progressing EPC Companies in the field of establishing Solar Photovoltaic power plants on a PAN India basis. He is often recognized for fostering transformation in his business and bringing something new and better for society. Securing his interest in futuristic technology such as solar energy storage, smart grid, EV solutions and now Green Hydrogen, he aims to reformulate energy production and utilization & emphasize the importance of new innovative business models to grow and make a carbon-free world.

Webinar on **"Making Sense of Green Hydrogen"**

Mr. Kiran Kumar Alla
Senior Director
Plug Power Inc.

Scan to Watch the Session on SCGJ YouTube Channel or Click Here

Speaker Profile

Kiran Kumar Alla - Senior Director, Product Marketing in Plug Power Inc. At Plug he is actively working on furthering Green Hydrogen adoption in various sectors. Kiran Kumar Alla is an Electrical Engineer with an MBA in Finance and Marketing from Indian School of Business.

He started his career as a shop floor maintenance engineer for 7 years then shifted to HR Consulting with focus on Learning and Development for 5 years. He then went to ISB for his MBA and moved back to Electricity sector - 5 years Business Development in Power Transmission sector followed by another 5 years with Delhi Electricity Distribution Utility in various roles including as Head of Central Engineering Services and Renewables. He then joined Bloom Energy, a leading player in the Stationary Fuel Cell space. At Bloom, he worked on India Business Development, Product Management and Business Development in Marine sector.

Webinar Summary

Considering the amount of buzz around Green Hydrogen, and generally about Hydrogen, it is a good idea to understand few things about Hydrogen instead of swinging between the extremes. Green Hydrogen has emerged as one of the important elements in the path to decarbonization. As per IEA, "Hydrogen is an increasingly important piece of the net zero emissions by 2050 puzzle". Green Hydrogen is expected to play three main roles – One, as a means to decarbonize Grey Hydrogen currently in use, second as a means to decarbonize hard to abate sectors and lastly as a Long Duration Energy Storage (LDES) medium.

It is estimated that we globally use close to 100 Million Tonnes per Annum (MTPA) of grey Hydrogen. Grey Hydrogen is produced mainly through steam methane reformation of natural gas with CO_2 emissions of >10kg/kg of Hydrogen. If Grey Hydrogen is replaced with Green Hydrogen produced through Water Electrolysis powered by Renewable Energy, we would be able to reduce a billion tonnes of CO_2 emissions annually, which is close to 2% of Global GHG emissions. Industries that currently use Hydrogen are Refineries, Ammonia, Chemical industries etc. Shifting to Green Hydrogen in these sectors is relatively easy as they already use Hydrogen and the main challenges would producing Green Hydrogen in required quantities and the additional cost for Green Hydrogen.

Coming to the hard-to-abate sectors, one challenge of decarbonization journey is to decarbonize electricity, which currently has a share of ~20% in the end use carriers of energy, while rest of the 80% we use is in the form of oil, gas, coal, biofuels, and waste. Even if we assume share of electricity grows to 40% by 2050 and is mostly decarbonized, we still need to address to the rest 60% energy used. This is where Green Hydrogen acts as a complementary energy carrier to electricity and start decarbonizing various industry sectors. Industries such as Steel, Road freight, Shipping, Aviation, Trains etc. can use Green Hydrogen to decarbonize those applications that cannot be electrified easily. While decarbonization is an important goal, these sectors might need to make changes to utilize Green Hydrogen and will be sensitive to the additional cost of Green Hydrogen as substitute to existing fuels.

In the ultimate scenario of a fully or majorly decarbonized world, major electricity generation is expected to be from Solar and Wind plants. As we all know, Solar and Wind are variable and uncertain sources and may generate more than what is required at a given minute. In such case, such excess electricity is needed to be stored for later use. Solutions such as Batteries are already available for short term storage. Pumped storage subject to geological challenges is available for longer duration storage while other solutions such as compressed air and gravity-based storage are under exploration. For truly long term and large quantity storage of energy, Green Hydrogen has been found to be a great solution either directly or as Ammonia and methanol, which can be easily stored and transported.

To summarize, Green Hydrogen is a complementary solution to Electric Grid and both these energy carriers can decarbonize our Energy Systems.

The Momentum for Green Hydrogen is expected to gain through:

1. Green Hydrogen achieving Scale

2. Wider Reach of Green Hydrogen

3. Green Hydrogen as a Sustainable Energy Carrier

To conclude, Green Hydrogen, while appearing to be a daunting technical and economical challenge is highly promising towards decarbonizing human activity and bring back climate change into control. Majority of countries either already have a Green Hydrogen plan or policy in place or in the making. United States and Europe have already announced large scale incentives for adoption of Hydrogen. Government of India has notified with National Green Hydrogen Mission in January 2023 and is fast operationalizing various incentives. Government of India is also exploring how to support Indian Industry become leading exporters of Green Hydrogen / Ammonia. We can expect large scale activity in the sector in the coming years. Exciting times ahead!

Scan to Watch the Session on SCGJ YouTube Channel or Click Here

Dr. Raman has done his doctorate from Pondicherry University, on syngas production through biomass gasification and its applications for power generation, industrial thermal applications and transport sector. Dr. Raman is the director of "Energy Efficiency and Environment P. Ltd." New Delhi, India. Having more than 40 years of experience, acquired a strong subject expertise on renewable energy technologies. Dr. Raman has extensively worked on several renewable energy products in the areas of biomass gasification, biogas plants and solar ponds. Worked on rural electrification projects using biomass gasifier based power plants in India and abroad. Extensively studied solar PV based micro grid, Island gid of biomass power plants. He has also developed many patents and also authored many papers in international journals. Currently Dr. Raman's focused research are design and development of biomass-steam gasification system to produce hydrogen rich syngas for production green hydrogen, development of high efficient and clean combustion biomass cookstoves burner and innovative solar cook-top using concentrated solar collector with hybrid thermal storage system.

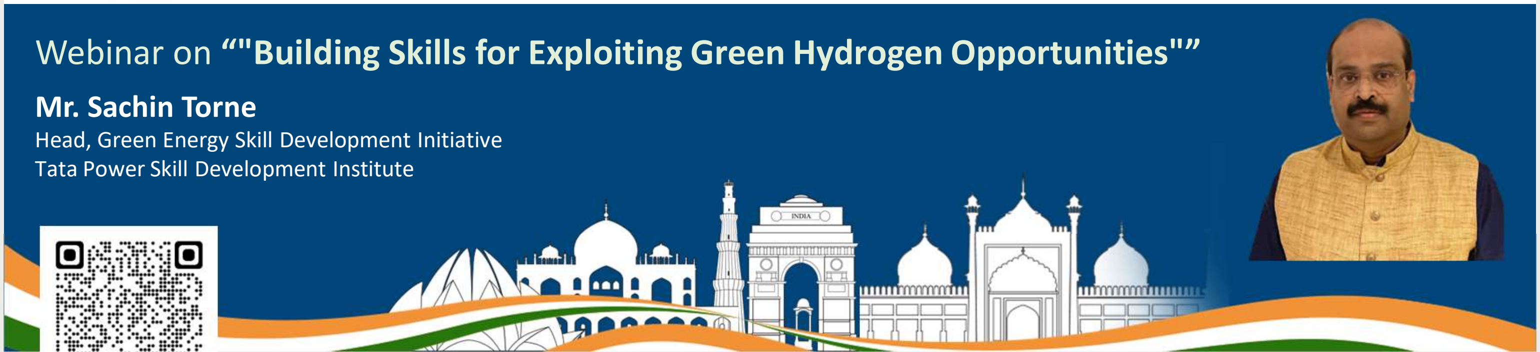
Webinar Summary

In the background of increasing interest in green or low carbon hydrogen globally in the last couple of years, the drivers of green or low-cost hydrogen were discussed. In this context, decarburization, energy security, shift away from fossil fuels and increasing emphasis on renewables, need for having an energy storage medium with variable renewable energy, utilization of curtailed renewable power and versatility of hydrogen as an energy carrier were identified as some of the drivers of green hydrogen. It was mentioned that there have been waves of interest in hydrogen energy in the past which turned out to be mere hype as not much progress was witnessed on the ground. This time it looks that interest in green hydrogen may turn out to be a reality due to involvement of all the stakeholders and Governments of different countries coming out with their policies and strategies for promoting development and deployment of low carbon hydrogen. There was a need for having a globally accepted definition of green hydrogen for promoting its global trade. In this context, the initiative taken by India in coming out with green hydrogen standard was mentioned. Information regarding global hydrogen production in 2021, its use in different industries such as oil refineries, ammonia synthesis units, methanol production and steel making; and the different feedstocks that were employed for its production was shared. Projections for global hydrogen requirement and likely share of green/low carbon hydrogen in 2030 and overview of green hydrogen production processes, hydrogen storage, transport and distribution was shared. A brief account of hydrogen application with special reference to hydrogen blending with natural gas to kickstart applications of green hydrogen was discussed. Data about hydrogen production and consumption as on 1.4.2020 in India by different industries was shared and the impact on requirement of hydrogen due to import substitution of urea, DAP and ammonia was also highlighted. It was mentioned that there could be requirement of about 8 MT of hydrogen in India excluding requirement for green steel making inBiomass is a potential renewable energy source and it is carbon neutral. In the remote and rural areas 90% of the total energy demand is met by biomass (agricultural residues. Biomass is a low cost fuel compared to fossil fuels. Biomass gasification is a technically and economically viable option for decentralised power generation. Green hydrogen production through biomass gasification is highly efficient technology in comparison to hydrogen production from natural gas or through electrolysis from renewable power. Hence, biomass gasification is an efficient clean energy solution for power generation and hydrogen production to meet the energy requirement in the transport sector. Energy Efficiency and Environment Pvt. Ltd. designed and developed an advanced three stage (ATS) biomass gasification system, which will produce high quality syngas (without tar) The ATS biomass gasifier system is designed to use multiple types of biomasses (woody biomass, loos biomass or briquette/pellets). ATS biomass gasifier is designed as a containerized system which reduces the duration and complexity involved in field installation. Cleaner syngas of ATS gasifier is highly suitable for power generation and green hydrogen production.

Biomass -steam gasification using oxygen as oxidizing agent for gasification produces hydrogen rich syngas. Biomass-steam gasification without using any catalyst can produce the syngas with 50% of hydrogen content. Biomass-steam gasification with use of catalyst can produce the syngas with 73% of hydrogen content. With conventional gasification technologies, presence of tar was a great problem in separation of hydrogen from syngas (using pressure swing adsorption (PSA) equipment). The tar-free syngas from ATS gasifier is suitable for a trouble-free and durable operation of PSA, and hydrogen production.

While the efficiency of hydrogen production using natural gas and coal are 78% and 62% and through electrolysis process using the power generated from wind and PV are 35% and 14%. The estimated value of green hydrogen production. Through ATS biomass-steam gasification is 79%. (It is possible to produce green hydrogen from biomass at a cost of less than one $/kg.).

coming years. Current high cost of green hydrogen; almost negligible share of electrolytic hydrogen and very slow rate of its growth; appropriateness of PEM eletrolyser technology for India in view of need for importing noble metals, reserves for which are scarce and located in only a few countries; cost competitive production of electrolysers and BOP; ramping up of renewable energy capacity at a unprecedented pace and scale required for production of 5 MT of green hydrogen by 2030; huge cost reduction needed in renewable electricity cost to achieve cost goal of less than $2/kg by 2030; water stress situation that may get aggravated due to electrolytic green hydrogen production; and focusing on internal demand alone or to also export green hydrogen were mentioned as some of the challenges for development of green hydrogen sector in India.



Scan to Watch the Session on SCGJ YouTube Channel or [Click Here]

Speaker Profile

Mr. Sachin Torne, a seasoned electrical engineer with an MBA, boasts over 35 years of versatile experience spanning the electrical engineering industry, ITES (Information Technology Enabled Services), and Edtech (Education Technology) sectors. Currently, Sachin Torne holds leads the Green Energy Skill Development Initiative at Tata Power Skill Development Institute. Widely recognized for his wealth of knowledge and insights, Sachin Torne passionately advocates for the widespread adoption of green hydrogen, underscoring its crucial role in sustainable energy solutions. Their impactful presentations resonate with audiences, and their commitment extends to nurturing the next generation of green energy professionals through innovative skill development initiatives. Sachin Torne's visionary outlook drives innovation towards a greener, more sustainable future in the realm of energy.

Webinar Summary

Building skills for Green Hydrogen jobs globally is crucial for achieving a sustainable and low-carbon future. By 2030, the green hydrogen sector is projected to create approximately 30 million jobs worldwide, making it one of the most promising avenues for employment growth. In India alone, there is a demand for around 6 lakh jobs in the Green Energy sector, highlighting the significant role it can play in addressing unemployment challenges.

To develop a skilled workforce, a systematic approach is essential. This begins with identifying skill gaps within the industry, charting the required skills for various positions, and designing tailored curricula for training programs. Collaboration among governments, academic institutions, and industry stakeholders is paramount in this endeavor.

Governments can provide the necessary policy support, funding, and incentives to encourage skill development initiatives. Academic institutions play a pivotal role in creating and delivering training courses, while industry partnerships ensure that training aligns with real-world demands. Moreover, the establishment of training infrastructure and the development of subject matter expertise are integral to the process.

In conclusion, building skills for Green Hydrogen jobs is not only a response to the global demand for sustainable energy but also an opportunity to foster economic growth and create millions of meaningful, well-paying jobs. A collaborative approach among stakeholders will be key to harnessing the full potential of the Green Hydrogen sector in meeting these objectives.

Webinar on **"Potential of Hydrogen as a Clean Fuel for Transportation in Today's Perspective"**

Dr. Jayakrishnan Krishnanaunni

Architect

Bosch Global Software Technologies Pvt. Ltd.

Scan to Watch the Session on SCGJ YouTube Channel or [Click Here]

Speaker Profile

Dr.Jayakrishnan has over all work experience of over 12 years in the field of research and development and project management. He is currently working as an Architect with BGSW since 2018. He has experience of working with different Indian and Japanese automobile OEMs and has been part of BS6 stage emission complaint vehicle development for different OEMs. Prior to joining Bosch, he was working as a Project Scientist at IIT Delhi and has handled several research projects during his tenure. His research topic included development of low emission vehicle for transportation with focus on Hydrogen, biofuel etc. He was awarded the degree of Doctor of Philosophy (Ph.D.) for work in the field of application of hydrogen fuel for automotive application from IIT Delhi in 2018. He also holds M.Tech degree in Energy & Environment management from IIT Delhi and B.Tech in Automobile Engineering from University of Kerala. He has several publications in reputed international journals. He has presented his research in several reputed conferences and has won awards on its merit.

Webinar Summary

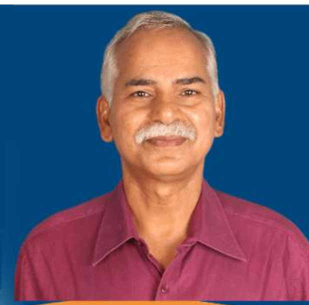
Combating the climate change and energy security has driven the nations across globe to aggressively pursue clean energy solutions. Hydrogen one of the most abundant element which act as an energy carrier has been considered key to achieving the above mentioned goals.

The session focused on the application of hydrogen as fuel for transport sector. Different ways in which hydrogen can be used in the transportation sector such as the internal combustion route, the fuel cell routes were discussed along with overview and merits of both the technologies. The maturity of these technologies at the current point of time were also discussed. The session also discussed how hydrogen R&D was driven by MNRE, GoI and discussed about some major hydrogen-based demonstration projects for transportation undertaken by IIT Delhi, Mahinda & Mahindra, Tata Motors, CSIR, KPIT etc. Challenges faced for the technology implementation such as cost of production of hydrogen, policy support and regulatory changes, storage, transportation and dispensing of hydrogen (infrastructure development) etc were discussed.

Azadi Ka Amrit Mahotsav | Skill India | Government of India Ministry of Skill Development & Entrepreneurship | SCGJ Skill Council for Green Jobs

Webinar on "Green Hydrogen: Opportunities and Challenges"

Dr. M R Nouni
Adviser (Retd.)
MNRE, Govt. of India



Scan to Watch the Session on SCGJ YouTube Channel or Click Here

Speaker Profile

Dr. M R Nouni has been associated with power and renewable energy sectors for nearly four decades. He worked at the Ministry of New and Renewable Energy (MNRE), Government of India (GoI) in different capacities for about three decades and was involved in policy formulation and implementation of Research, Development and Demonstration programmes of the MNRE. During the last two decades his efforts were mainly focused on activities related to development of hydrogen energy at MNRE and National Institute of Solar Energy, an autonomous institute of MNRE. At MNRE, He was actively involved in preparation of the National Hydrogen Energy Roadmap, 2006 and the Report of the Steering Group on Hydrogen Energy and Fuel Cells in 2016. After his superannuation as Adviser from MNRE in 2016, he worked as a Senior Consultant at NISE for six years and was associated with projects related to hydrogen energy and solar thermal at the Institute. Earlier, he had worked at Bharat Heavy Electricals Ltd in their thermal power business group in 1980s. His research work relating to techno-economics of renewable and hydrogen energy and energy policy has been published in peer reviewed international journals.

Webinar Summary

In the background of increasing interest in green or low carbon hydrogen globally in the last couple of years, the drivers of green or low-cost hydrogen were discussed. It was mentioned that there have been waves of interest in hydrogen energy in the past which turned out to be mere hype as not much progress was witnessed on the ground. This time it looks that interest in green hydrogen may turn out to be a reality due to involvement of all the stakeholders and Governments of different countries coming out with their policies and strategies for promoting development and deployment of low carbon hydrogen. There was a need for having a globally accepted definition of green hydrogen for promoting its global trade. In this context, the initiative taken by India in coming out with green hydrogen standard was mentioned. Information regarding global hydrogen production in 2021, its use in different industries such as oil refineries, ammonia synthesis units, methanol production and steel making; and the different feedstocks that were employed for its production was shared. Projections for global hydrogen requirement and likely share of green/low carbon hydrogen in 2030 and overview of green hydrogen production processes, hydrogen storage, transport and distribution was shared. A brief account of hydrogen application with special reference to hydrogen blending with natural gas to kickstart applications of green hydrogen was discussed. Data about hydrogen production and consumption as on 1.4.2020 in India by different industries was shared and the impact on requirement of hydrogen due to import substitution of urea, DAP and ammonia was also highlighted. It was mentioned that there could be requirement of about 8 MT of hydrogen in India excluding requirement for green steel making in coming years. Current high cost of green hydrogen; almost negligible share of electrolytic hydrogen and very slow rate of its growth; appropriateness of PEM eletrolyser technology for India in view of need for importing noble metals, reserves for which are scarce and located in only a few countries; cost competitive production of electrolysers and BOP; ramping up of renewable energy capacity at a unprecedented pace and scale required for production of 5 MT of green hydrogen by 2030; huge cost reduction needed in renewable electricity cost to achieve cost goal of less than $2/kg by 2030; water stress situation that may get aggravated due to electrolytic green hydrogen production; and focusing on internal demand alone or to also export green hydrogen were mentioned as some of the challenges for development of green hydrogen sector in India.

Webinar on "Paradigm Shift in Energy Sector through Green Hydrogen: Strengths and Gaps""

Dr Perminder Jit Kaur
Senior Policy Fellow
Indian Institute of Science, Bangalore, India

Scan to Watch the Session on SCGJ YouTube Channel or Click Here

Speaker Profile

Dr. Perminder Jit Kaur is a chemical engineer with doctorate in rural development technologies from IIT Delhi. Her research on biomass treatment and characterisation was awarded with the "Prof. Meera Madam Best Ph.D. Thesis" from IIT Delhi. Earlier, her experience as an Assistant Professor at the University School of Chemical Technology, Guru Gobind Singh Indraprastha University, New Delhi, which has helped her to go deeper into policy, and green energy technologies. As a Project Scientist in the Government of India's Unnat Bharat Abhiyan, she has also worked on the village development plans. The Mentor of Change program of Niti Aayog has given her a platform to inculcate scientific temper among school children.

Presently, she is working as a Senior Policy Fellow at the Department of Science and Technology's Centre for Policy Research, IISc, Bangalore. She is working on investigations of policy Level Interventions Required for Bioenergy and Green Hydrogen in India.

She has authored one book on the Sustainable technologies for waste management, published various book chapters, and research papers in refereed journals of repute. She is passionate about decentralized solutions for multi-sectoral environmental, climate change, and renewable energy policy issues.

Webinar Summary

The environmental effects of expensive and non-renewable fossil fuel-based energy sources have motivated the government and industrial sector to explore alternative clean, renewable, and low-cost energy sources. Hydrogen, with a high energy density (122MJ/Kg), is a renewable, non-carbon-based, environment-friendly fuel. Hydrogen is graded as blue, brown, and grey depending on the raw materials and technology adopted. Renewable energy like solar or wind-driven electrolyzers can generate environment-friendly Green Hydrogen (GH). The paradigm shift in the energy sector will require coordinated efforts of various stakeholders working on the four major domains of GH, i.e., production, storage, transportation, and application. The National Hydrogen Mission by the Government of India also focuses on developing a national production capacity of 5 MMT annually. Stakeholder analysis suggests that financing hydrogen production and applications is vital to this transition. There are associated challenges like designing, developing, and deploying suitable scalable skills programs in the country. Skill Council for Green (SCGJ) is also taking timely actions to build skill sets in these emerging areas of the energy sector through suitable courses and programs.

Further, to strengthen the renewable energy sector, reasonable steps are required to generate a talent pool in different GH domains. Providing concessional funding, capacity building of industries, academic institutes, and multi-stakeholder trans-disciplinary collaboration can help ease this transition in energy sector. To effectively control climate change and global warming collectively, international cooperation in developing standards and technologies can play an essential role in creating a global hydrogen energy market. With proper policy support, enhanced public-private partnership, and skill-set generation, India can become a worldwide leader in the energy sector and achieve its target of net zero-carbon emission by 2070.

Events & News

Skill Council for Green Jobs

SCGJ, in association with GH2 Solar and NSEFI - National Solar Energy Federation of India , organised a two-day masterclass on green hydrogen entrepreneurship on 4th and 5th Sept, 2023.

Skill Council for Green Jobs participated in the 03rd National Apprenticeship Awareness Workshop for Gujarat at Daman for the UT of DNH and DD on October 13, 2023, organized by RDSDE, Gujarat

Skill Council for Green Jobs (SCGJ) was honoured to be a part of the 4th ICRABR event organized by Sardar Swaran Singh National Institute of Bio-Energy (SSS-NIBE) on October 11th 2023

SCGJ organized online competitions as part of the "Green Energy Skills Championship".

COO, SCGJ visited BIBB, Federal Institute for Vocational Education and Training. Green TVET in Germany was organized as part of the Indo- German Programme 25th September 2023

Dr.(Mrs) Parveen Dhamija, Advisor, SCGJ invited as Speaker on special session on ‘ Skill Development & Capacity Building for Clean Energy Transition’ on 22nd September 2023

Solar Skill Training and Competition supported by M/s GOODWE on 13th October 2023

Panel Discussion on Mainstreaming Persons with Disability in Green Energy Sector' hosted by SCPwD and SCGJ on 13th October 2023

SCGJ participated in Panel Discussion on Skill Gap in Renewable Energy Workforce, Vietnam on 19th October 2023

Skill Council for Green Jobs (SCGJ) and the Australian Trade and Investment Commission had a fruitful meeting on skill collaborations at the Australian High Commission, New Delhi, on October 17, 2023.

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